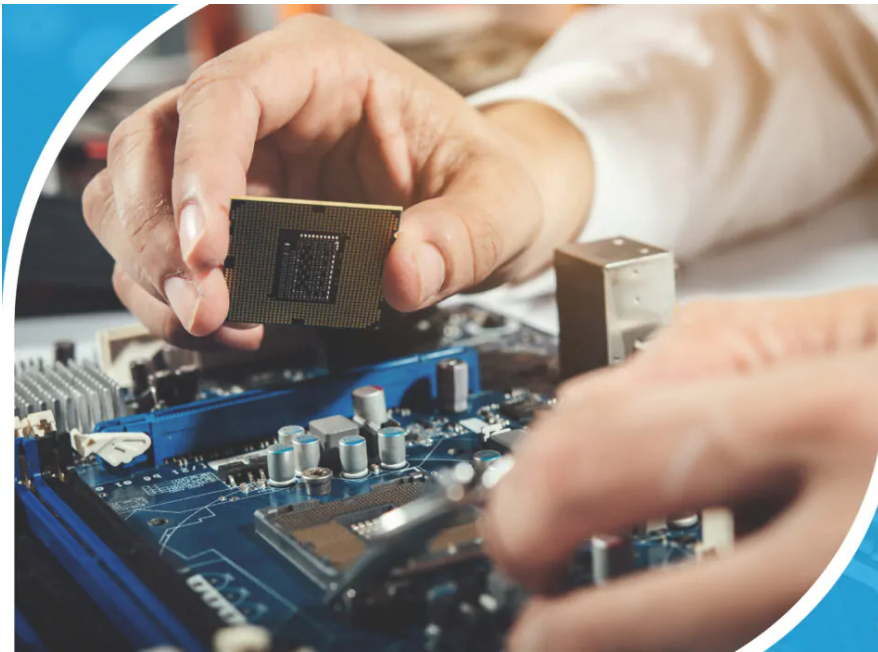




Embedded System

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An embedded system can be described as a computer that performs functions in a unique electrical mechanical system. It is comprised of a computer's processor memory, memory, as well as common input and output devices. It's usually found as part of a bigger device that has both electrical/electronic technologies & mechanical components. Real-time computing is a requirement for embedded systems because they are the main controllers of machine operation regardless no matter where they are located. These systems control a wide range of devices. This blog will let you learn more about embedded systems along with the advantages and disadvantages.

How does an embedded system work?

An embedded system is a specialized computer system designed to perform dedicated functions within a larger system. It typically consists of a microcontroller or microprocessor, memory, input/output interfaces, and sometimes additional peripherals. These systems are programmed to carry out specific tasks and are often found in everyday devices such as appliances, automobiles, medical devices, and industrial machines. Embedded systems operate in real-time, meaning they must respond to external events within strict timing constraints. They are often optimized for low power consumption, compact size, and high reliability to meet the requirements of their intended applications.

The functionality of an embedded system is defined by its software, which is typically developed using programming languages like C or C++. This software controls the behaviour of the system, processing inputs from sensors or user interfaces and generating outputs to control actuators or display information. Embedded systems can operate autonomously or communicate with other systems through various interfaces such as serial communication, Ethernet, or wireless protocols. Their design requires careful consideration of factors like

power management, memory usage, and real-time responsiveness to ensure they perform their tasks efficiently and reliably.

Types of embedded systems

The top four types of embedded systems include:

Real-Time Embedded Systems

These systems respond to inputs and produce outputs within strict timing constraints, crucial for applications like automotive control systems and medical devices.

Networked Embedded Systems

Interconnected with other devices via wired or wireless networks, they enable communication and data exchange, prominent in IoT devices and smart home systems.

Mobile Embedded Systems

Optimized for mobility and portability, they power devices like smartphones, tablets, and wearable technology, providing user interfaces and processing capabilities on the go.

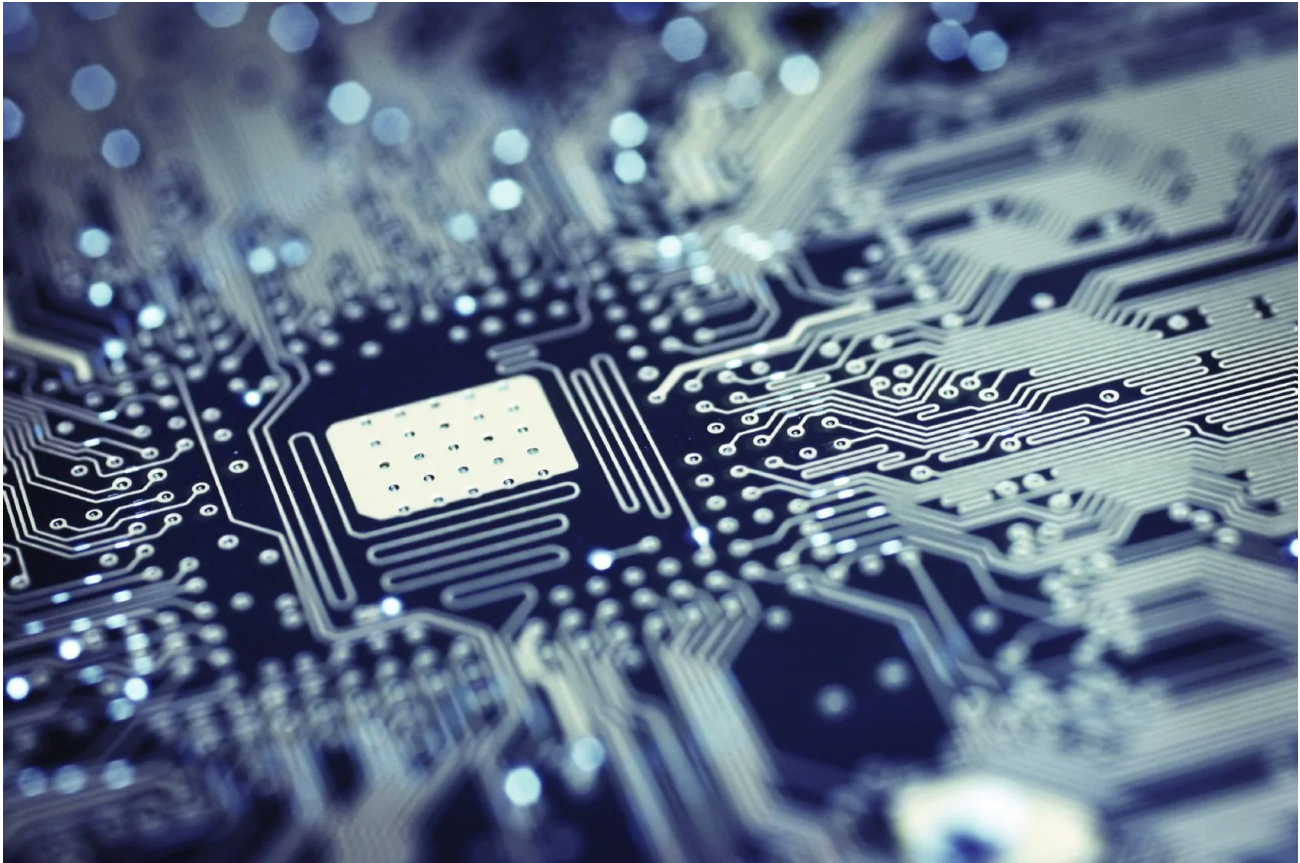
Embedded Systems for Specific Applications

Tailored for specialized tasks or industries such as aerospace, defense, healthcare, and industrial automation, they provide customized solutions for specific functions and requirements.

Features

In contrast to being an all-purpose computer that can be used for various tasks, the embedded systems are designed to perform a specific task. Additionally, some of them have real-time performance limitations due to reasons related to safety and usability. Others may have weak or no desire to perform in order so that the hardware to lower cost. Many embedded systems are comprised of smaller components within a bigger device, which serves a more general goal. An embedded system inside an automobile has a distinct role as a subsystem within the vehicle itself. The instructions for programs designed specifically for the embedded system are known as firmware. They are stored as read-only memories or Flash memory chips. They operate with limited hardware integration components of computers like an insignificant screen, a non-existent keyboard, and very little memory.





Source: The Engineering Projects

Components of Embedded Systems Programming

- Microprocessors/Microcontrollers
- Peripherals
- Sensors & Input devices
- Actuators & output devices
- Registers
- Protocols

Microprocessor:

The microprocessor is a processor that integrates the functions of central processing units on one IC. Microprocessors are a flexible register-based, clock-driven integrated circuit. As input, it receives binary data, processes it according to the instructions that are stored within its memory and then outputs results.

It's an IC that only contains one processor (Processing energy).

Some applications perform tasks that are not defined, such as developing games or websites, editing photos and more.

They operate operating systems.

Microcontroller:

A microcontroller is a computer that is embedded in a chip. Contrary to computers, which comprise many distinct parts, the microcontroller has every CPU (Processor cores) as well as memory and peripherals for input and output. This allows you to create systems that have small parts.

It is equipped with a CPU as well as RAM, ROM, and various other peripherals on one chip.

They are specifically designed to complete specific tasks. (i.e., cars, bikes, microwaves)

They operate in bare metal

Peripherals

A peripheral device or peripheral is a device that acts as an auxiliary device to input information into or obtain information from a computer. Systems embedded in the computer communicate with the outside world via peripheral devices. Here are some an example of peripherals.

- SCI, also known as Serial Communication Interfaces RS-232, RS-422, RS-485 and so on.
- Synchronous Serial Communication Interface: I2C, SPI, SSC
- Universal Serial Bus (USB)
- MMC (also known as Multimedia Card) (SD cards, Compact Flash, etc.)
- Networks: Ethernet, Lon Works, etc.
- Fieldbuses: CAN-Bus, LIN-Bus, PROFIBUS, etc.
- Timers: PLL(s), Capture/Compare as well as Time Processing Units
- Analog to Digital/Digital Analog (ADC/DAC)

Sensors & Input devices

Sensors are highly sophisticated devices that are typically employed to detect and respond to optical or electrical signals.

Examples:

- Sensor for temperature
- Infrared (PIR) sensor
- Touch sensor
- Pressure sensor

Actuators & output devices

An actuator is one of the components of a machine responsible for controlling and moving the system or mechanism such as opening an air valve.

Example:

- Electric motor

- Screw Jack
- Hydraulic Cylinder

Registers

A processor register, also known as a CPU register, is a tiny storage location for data which are essentially slices of the processor of a computer. Registers can hold an instruction or a storage address or any other type of data like a small sequence of characters or even a separate one. Many commands require registers in the instruction. For example, instructions can specify for the data of two distinct registers to be merged and then put into a specific register.

Protocols

A protocol is a common set of rules that allow electronic equipment to connect. These rules define what kind of data may be sent and what commands are used to transmit data and receive it, and how data transfer is confirmed.

Examples:

- Inter-Integrated Circuit
- SPI Serial Peripheral Interface
- USART/UART: Universal Synchronous/Asynchronous Receiver Transmitter.

Embedded System Advantages

We will go over the many benefits of an embedded system, for example, embedded system benefits.

- Simple to produce more production.
- Less expensive prices each piece of the resultant
- It has only a few interconnections.
- More stable
- More reliability
- Portable due to the small size
- Low power consumption
- Accurate results with better accuracy
- More speed
- To maximize resources like microprocessors and memory
- It can withstand a vast range of environments.
- It is less likely to repeat errors.
- To provide real-time response
- It is not user-friendly.
- Not much data storage
- Lesser redundancy
- To run pre-planned programs to run user applications



Because an embedded system generally plays a role that does not change its requirements, the requirements for an operating system aren't as burdensome.

Embedded System Dis-Advantages

There are certain **limitations to embedded systems** for example, as

- Once an embedded system is developed You are not able to alter, enhance or upgrade.
- It is difficult to keep
- It is difficult to create a backup of embedded files
- It is necessary to reset every setting to avoid any issues with the system.
- Troubleshooting is harder
- It is more difficult to transfer data across systems to another system.
- Hardware limitations, due to its use for certain tasks
- Power supply reliability is less durable.
- Memory is limited and resources are not sufficient.
- To require more development efforts to design an embedded system

Applications of Embedded Systems

Embedded systems find applications in a wide range of industries and domains due to their versatility, reliability, and efficiency. Some common applications include:

Consumer Electronics

Embedded systems power devices like smartphones, smart TVs, digital cameras, and gaming consoles, providing user interfaces, processing capabilities, and connectivity features.

Automotive

Embedded systems control various functions in vehicles, including engine management, anti-lock braking systems (ABS), airbag deployment, navigation systems, entertainment systems, and advanced driver-assistance systems (ADAS).

Industrial Automation

Embedded systems are used in industrial machinery, robotics, programmable logic controllers (PLCs), and process control systems to automate manufacturing processes, monitor equipment, and optimize efficiency.

Healthcare

Embedded systems play a crucial role in medical devices such as pacemakers, insulin pumps, infusion pumps, patient monitoring systems, and diagnostic equipment, enabling precise control, monitoring, and data collection for healthcare professionals.

Home Automation

Embedded systems control smart home devices like thermostats, security cameras, door locks, lighting systems, and appliances, allowing users to monitor and control their homes remotely for convenience, security, and energy efficiency.

Aerospace and Defense

Embedded systems are utilized in aircraft avionics, navigation systems, communication systems, radar systems, unmanned aerial vehicles (UAVs), and missile guidance systems, providing critical functionality for flight control, surveillance, and defense operations.

IoT (Internet of Things)

Embedded systems form the backbone of IoT devices, enabling the connectivity and communication of sensors, actuators, and smart objects in various applications such as smart cities, environmental monitoring, agriculture, transportation, and logistics.

Telecommunications

Embedded systems are used in networking equipment, routers, modems, and base stations to manage communication networks, ensure data transmission, and provide services like voice over IP (VoIP) and video streaming.

These are just a few examples of the diverse applications of embedded systems, demonstrating their pervasive presence in modern technology and society.

Embedded System Trends

Emerging trends in embedded systems are revolutionizing technology. Integration with the Internet of Things (IoT) is expanding connectivity and intelligence in devices, while edge computing enables local data processing for faster response times. AI and ML capabilities are enhancing decision-making and autonomy, while security measures ensure data protection. Additionally, a focus on energy efficiency drives innovations for sustainability. These trends are reshaping industries and driving innovation in embedded systems.

Final Words

The embedded system industry is expected to grow rapidly, driven by the continuous advancement of Artificial Intelligence (AI), Virtual Reality (VR) and Augmented Reality (AR), deep learning, machine learning and the Internet of Things (IoT) development. Cognitive embedded systems will form the centre of these trends, including the reduction of energy use, enhanced protection for devices embedded in cloud connectivity, mesh networks, deep learning applications as well as visualization tools that utilize real-time data. I am hoping that

this information will assist in understanding the significance of embedded systems as well as their pros and cons advantages.

FAQs

What is an embedded system with examples?

An embedded system is a specialized computer system designed to perform specific tasks within a larger device or system. It is typically embedded into the hardware of the device and is dedicated to executing pre-defined functions. Embedded systems are commonly found in everyday devices such as household appliances, automobiles, medical devices, and industrial machinery.

How are embedded systems programmed?

Embedded systems are typically programmed using programming languages like C or C++. The software is developed to control the behaviour of the system, process inputs from sensors or user interfaces, and generate outputs to control actuators or display information.

How are embedded systems evolving?

Embedded systems are evolving with advancements in technology, including integration with IoT, AI and ML capabilities, and increased connectivity for smarter and more efficient devices.

Can embedded systems be reprogrammed or updated?

In some cases, yes. Many modern embedded systems support over-the-air (OTA) updates, allowing for reprogramming without physical access to the device.

What are real-time embedded systems?

Real-time embedded systems are designed to respond to external events within strict timing constraints. They are commonly used in applications where timing is critical, such as automotive control systems, medical devices, and industrial automation.

Disadvantages Of Embedded Systems

Embedded Software

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Embedded System Advantages

Embedded System Design

Embedded Systems Programming

Firmware Embedded System



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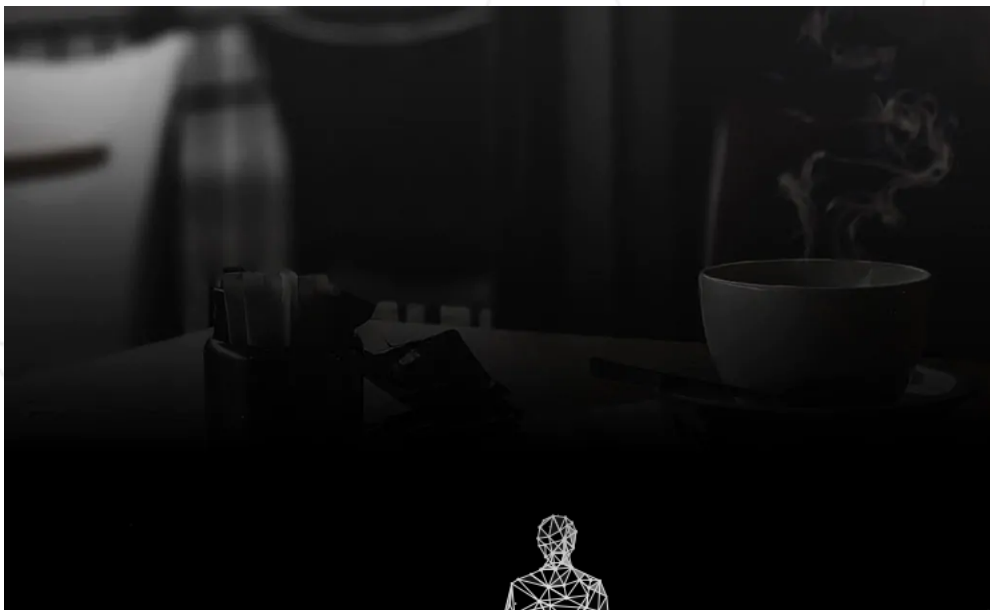
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