

## Embedded Hardware and OS Technology Empower PC-Based Platforms

*The modern embedded computer is a jack of all trades appearing in many forms*

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Everywhere we look we find computers. Many of them don't look like traditional desktops, or laptops. In industrial infrastructure, we find them in displays, in networking appliances, in machine controllers, in HMIs and in industrial controllers and PACs (programmable automation controllers). We find them in low power, portable devices, and even in field transmitters.

The first key to this development is the embedded processor. When PCs first appeared in the early 1980s, the processor chip was extremely expensive, and required special power supplies and cooling. It was not economically feasible to embed them in hardware and appliance type devices. Typically, smaller, lower capability processors were used, or hardwired digital logic was used. By the late 1980s and early 1990s, however, the cost to produce an Intel or AMD x86 level processor had reduced to the point where engineers and product designers found they could use standard "PC-level" processors instead of older, smaller, less capable designs like the venerable Z80 or Z88, or custom designed logical devices.

The very first convergence from this newfound ability was the ability to program in higher order programming languages like C, C++ and C#, thus opening the world of appliance design to the general run of programmers trained to program for the PC.

### **Figure 1: Embedded Processor Used in Managed Gigabit Ethernet Switch**

The next convergence was the very vastly increased capability to perform operations. The ability for the processor to perform highly complex native mathematical operations made it easy to give the device or appliance



features it never would have had before. Where previous generations might have lookup tables, modern embedded processors run the same mathematical models as desktop PC devices might run.

### **Figure 2: Embedded Single Board Computer**

For several years, the speed and performance of the embedded processor was held back by the unavailability of industrial grade, yet inexpensive peripherals and auxiliary equipment. In addition, the operating systems tended to be custom, which led to difficulties in networking devices and maintaining legacy instruments.



Finally, the second key appeared. The development of the tablet PC and the various Windows versions designed to run on low power portable PCs, PDAs and smartphones led concurrently to the design of industrial grade versions of these devices, for use as PACs, HMIs, graphical displays, and machine controllers. All of them were compatible with standard PC-based architecture for printing, networking, and keyboard and touchscreen input, and all of them ran some version of the Windows operating system designed specifically for such devices.

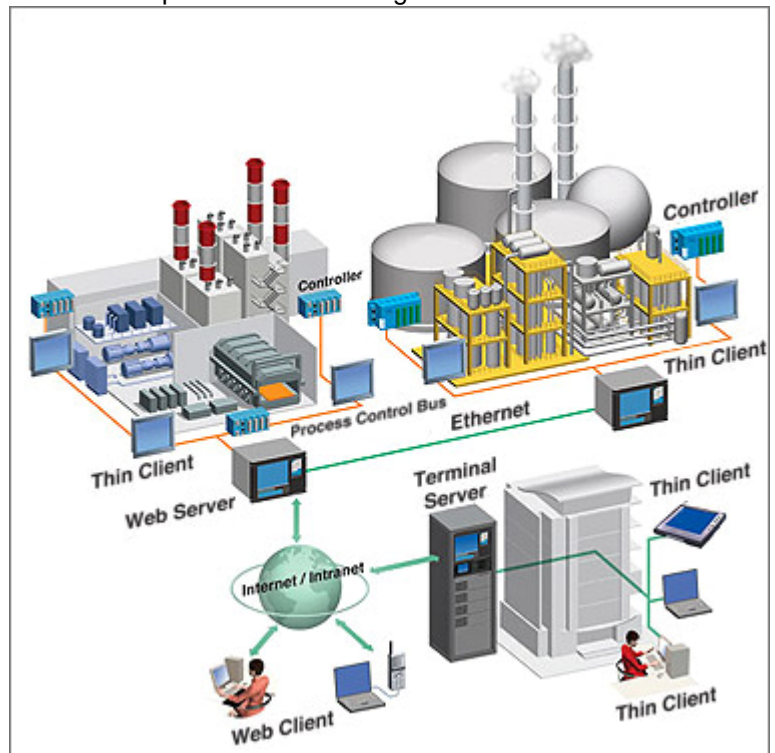
The increasing ubiquity of industrial Ethernet and USB hardware interconnection have also made the transition from single purpose designed processors to using embedded processors in a variety of guises not only possible but quite easy, and is the third key to the development of ubiquitous embedded computing. The touch panel display shown in Figure 3 is in fact a fully featured PC computer taking advantage of the embedded computer design. This “display” is really a PC designed with the Intel Pentium M 1.4 GHz/Celeron M 1 GHz processor as its core. The Intel Pentium M/Celeron M has low power consumption and 1.4 GHz/1 GHz operating frequency. This system is fanless although the kernel is powerful. This “display” is a fully networked computer, with embedded Ethernet, USB, RS-485, and even audio and video I/O ports.



**Figure 3: Embedded Computer Used as Touch Panel Display**

So what we see is a plethora of general purpose computing devices, performing the tasks that special purpose processors and devices were built to perform a decade ago.

**Figure 4: Enormous Multiplicity of Uses of Embedded Computers in Industrial Controls**



## Choosing Embedded Computing Devices:

Not all embedded computers are created equal. You cannot take just any PC off the shelf and install it in an industrial environment. It is important that the devices you select are suitable for the service you intend to use them in.

First, the design must have no moving parts. Especially when used in field devices such as touch screen panels, or distributed I/O modules, or even in network appliances such as the managed Ethernet switch in Figure 1, the design must be fanless. No cooler should be required for the CPU. The power supply must not require fan cooling, and there should not be a system fan either. This should not be at the expense of power and performance, either. The touch screen display panel shown in Figure 3 is a fanless design, operating at less than 60 W on an 18 to 32 VDC input.

Users often do not consider the HDD (hard disk) as a moving part, but it is a significant one. Solid state storage has improved to the point that commercially available CF (compact flash) and USB storage modules are available up to 8 Gb for less than \$100. The “display” in Figure 3 is capable of 1 CF and 4 USB storage cards, for a total of 40 Gb of storage, without fans or conventional HDD.

Additionally, it is very important that there be as few cables as possible to prevent failure from vibration. The embedded computer design should, as in the one pictured in Figure 2, have no internal cable connection. Every part should be soldered solidly to the circuit board.

In the industrial environment, it is imperative that the embedded device function over a wide range of ambient conditions. The display in Figure 3, for example, operates over a 0° to 50° C range, and can be stored at down to -20° C. The humidity range is important too. The display in Figure 3 is rated for 10 – 95% RH, non-condensing, at 40° C.

The industrial environment demands better construction than the commercial environment, as well. Embedded computing devices must meet industrial standards for enclosures. The display in Figure 3, for example, has a bezel that is constructed of aluminum-magnesium alloy, with an aluminum back panel, and is rated NEMA 4 and IP65 when installed in a panel.

### User Check List for Embedded Computing Features:

- Platform with no moving parts
  - Fanless design (no CPU cooler / no power supply fan / no system fan)
  - Diskless design (industrial grade CF for critical application / HDD option for non-critical environment)
  - Cable-less design (solder part instead of internal cabling)
- Compact-Size Design
  - Smaller (small footprint, save space, easy to install and easy to carry)
  - Lighter (better anti-shock / anti vibration)
- CPU Technology
  - Lower power consumption while providing better computing performance
  - Multiple cores which keeps empowering embedded platform performance
- Memory Technology
- Embedded O/S Technology
  - Robust
  - Full feature of O/S
- Flash Drive Technology
  - More reliable than HDD
  - Economical pricing

The design should be capable of running Windows' embedded OS. Embedding the operating system frees up storage for data and other essential operations. These embedded operating systems provide all of the features found in the RAM-resident versions, but are provided on flash memory so they boot up immediately on startup and do not require shutdown. These embedded computing devices make excellent notepads for wireless workers, as well as networking appliances, displays, field controllers and PACs.

**Figure 5: Programmable Automation Controller Uses Embedded Computing**



**All the Multiple Ways to Use Them**

As is clear from the proliferation of embedded computing devices seen in Figure 4, embedded computing is everywhere in the industrial environment. One of the most significant changes in the past few years is the growth in the PAC (programmable automation controller) market. Using the same embedded processor found in the display, in the network appliances, in the I/O modules, these devices are configured to do all the same functions as a hardwired or special purpose field controller was designed to do.



Taking the use of embedded computers even further, automation systems can be built using fully featured embedded automation computers, like the one shown in Figure 6. These types of device are designed from the bottom up to be used in the plant floor industrial environment. They conform to the checklist found in the sidebar in this paper, and use embedded operating systems like Windows XP-e (the embedded version of the common Windows XP operating system). Because they use a straightforward and widely used OS, there are few compatibility issues with peripherals, communications, networking and input/output devices.

**Figure 6: Embedded Automation Computer-- Tougher Than Industrial PCs**

This design's use of Windows XP embedded permits the use of optimized device drivers, and is more compact and reliable than even the general run of "industrial PCs." And they can be furnished in many different form factors. In Figure 7, for example, we see a Din-rail mounted version of an embedded automation computer that offers almost all of the same features of the larger version shown in Figure 6.



While its larger cousin runs Windows XP embedded, this Din-rail mount version runs Windows CE. This permits even lower power operation, while preserving the ability to run the same applications as any Windows-based PC.

**Figure 7: RISC-based Windows CE DIN-rail Mount--Yet It Is Fully Featured**

The device in Figure 7 even includes dual LAN ports, as well as multiple I/O ports and can be used for multiple applications, such as communications gateway, I/O module multiplexer, data collection and communication, and data storage—just by applying the correct program. System integrators can use these embedded automation computers to reduce the system complexity of projects.

Machine builders are able to use embedded automation computers to reduce the number of device types necessary to provide machine controls, and reduce the complexity of after-sale service and support requirements.

Embedded computing devices have changed the world of industrial automation. Users can be sure that selecting a device from a company with a wide selection of these devices will give them a platform that will perform successfully, regardless of the form factor the user selects for each individual device.

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