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How industrial-grade, PC-based automation can drive oil and gas integrated operations

High-performance, industrial-grade PCs are designed and engineered for reliable, continuous operation in the extreme environments typical of the oil and gas industry, to help lower costs and boost profitability.

White Paper

Abstract

As a PLC-based automation alternative, PC-based automation can help the oil and gas industry drive much wider adoption of integrated operations across its upstream, midstream and downstream value chain by connecting field-level control and monitoring with enterprise-level business applications. Advantages over PLC approaches include fewer functional components; integration of non-PLC functionality with traditional PLC control logic; and easier access to large data storage capacities, either onboard the PC itself or via separate storage area networks. But off-the-shelf PCs are unsuitable for the industry's typically extreme operating conditions and the high-stakes associated with regulatory compliance as well as environmental and life safety. While industrial PCs (IPCs) are designed and engineered for performance, reliability and durability – with ruggedization built-in, not added-on – they can offer the very latest PC processors and related technologies, so performance is never compromised.

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When just any PC won't do…

Visit enough industrial facilities and you're bound to eventually see it: A mission-critical process application controlled by an off-the-shelf PC that's subject to all sorts of adverse conditions – dust, heat, vibration and possibly even Class I hazardous surroundings. Chances are, the PC is likely the same brand and model you might buy for your home or office.

Talk about a weak link. And what you see may well be operating despite the facility having perhaps millions of dollars in feeder stocks awaiting processing, many millions more in orders pending fulfillment and perhaps scores of people whose jobs depend on that production line to keep moving.

In the oil and gas industry, the stakes can be even greater, not just in terms of cost but also because they can include heavy regulatory penalties, environmental damages and, most critically, the life safety of personnel and surrounding communities. That's all the more reason to entrust PC-based automation for oil and gas applications to specially designed and engineered industrial PCs (IPCs).

For integrated operations across the full length of the industry's upstream, midstream and downstream value chain, IPCs can offer a number of advantages in terms of reliability, durability, real-time operations, security, data protection and specialized form factors for deployment flexibility. But IPCs also need to withstand the industry's extreme and hazardous operating conditions with ruggedization built-in, not added on.

What is "integrated operations"?
The term "integrated operations" refers to the real-time gathering, consolidation and analysis of data spanning the entire oil and gas value chain, from upstream production to midstream transport and downstream refining. Upstream, it can connect the data spawned by an oilfield's entire operations, from the tip of a drill bit at the bottom of a bore hole to the flow of oil and gas out a pipeline to a refiner or consolidator. Producers can use these capabilities to make better, more informed decisions about how to optimize asset utilization, while gaining more operational visibility and information-sharing across their enterprises.

This paper offers insights into the comparative advantages of using IPCs over PLCs for monitoring and controlling various processes in oil and gas industry applications. It uses the inner workings and features of the Siemens SIMATIC line of high-performance IPCs to illustrate what distinguishes a heavy-duty IPC from its distant, off-the-shelf cousin. These features can also be used to compare IPCs from other manufacturers.

IPC or PLC? That is the question

Why use an IPC instead of a PLC for automation applications? Good question. With the advancements in PLC technology and functionality over the past decade, like in the Siemens SIMATIC

S7-1200 and S7-1500 model lines, PLCs are close to being multi-function computers themselves. But for all that, an IPC can perform nearly all the functions of a PLC, with these advantages:

■ **Fewer functional components needed for use in an application,** making a solution smaller and less expensive. For example, an IPC can consolidate such elements as the PLC itself, plus its HMI, normal and fail-safe controls and any customization that might be required.

■ **Integration of non-PLC functionality with traditional PLC control logic**, while providing process and industrial engineers with more opportunities to tailor their applications to specific requirements. IPCs can run PLC logic just as a PLC can. An example of this in the oil and gas industry would be to integrate a monitoring and control application in a driller's cabin with a producer's enterprise resource planning (ERP) system back at headquarters.

Sample IPC Applications
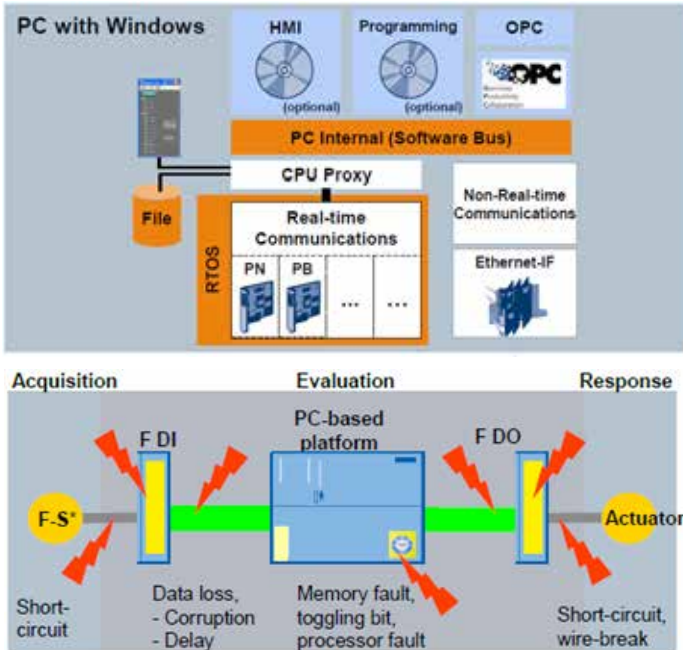**Data collection and conversion**
- Data recording directly at the machine
- Interface between machine and IT
- Link to corporate information systems

Automation tasks
- Control and visualization with one device
- Complex SCADA applications
- Flexible integration of PC hardware and software

Industrial servers and workstations
- PC applications in production
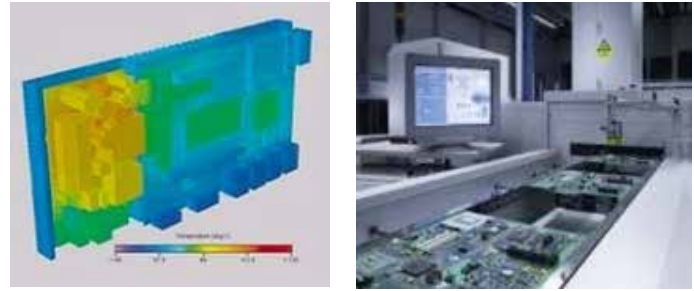- Machine-level server applications
- Data management in control rooms

■ **Large data storage capacities on-board or connected** (e.g., storage area networks) for various black-box applications that generate large amounts of data or in order to collect high-speed data from process applications. One SIMATIC IPC customer application, for example, generates 400KB of data every second – or 10.3GB per day – from an industrial, data-gathering application.

■ **Additional security mechanisms** not typically provided in a PLC or off-the-shelf PCs. For example, IPCs can use non-volatile random-access memory (NVRAM) to retain data when power is turned off, due to either a safety-related shutdown, power failure or some other system fault. This is in contrast to dynamic random-access memory (DRAM) and static random-access memory (SRAM) typical of office-grade PCs. Both maintain data only for as long as power is applied. Another example is PROFIsafe, a communication protocol used by WinAC on Siemens IPCs to ensure fail-safe operation by adding data security and time-constrained data delivery capabilities. PROFIsafe doesn't correct errors, but it puts the system into a safe state in the event of errors. Other security mechanisms include encrypted data storage and communications (e.g., VPN), as well as OEM licensing and compiled control algorithms to protect the intellectual property of application developers.

outdoors in desert or equatorial tropic environments, or in refinery operations – temperatures that can cook the insides of a standard PC. Models are available that are rated NEMA 4 and IP65 for protection against dust and water intrusion.

Other important points to note about SIMATIC IPCs include:

■ **High-performance.** With IPCs, there's no tradeoff of performance for reliability and ruggedness. Their CPUs can range from the energy-efficient Intel® Atom™ processor for applications with limited power sources, such as solar, or with limited power demands, such as data collection, to more powerful, fourth-generation Intel Celeron™, Xeon™ and Core™ i3, i5 or i7 processors. Up to 16GB of RAM can be factory-installed or easily upgraded later.

To protect data, IPCs use non-volatile RAM that retains its data if power is interrupted. This eliminates the need for costly and bulky backup UPS power systems. RAID-1 storage via solid-state drives (SSDs) provide additional data protection by creating a mirrored data set. More comprehensive RAID-5 storage is available. Built-in PROFINET and PROFIBUS with their own ports keep PCI card slots free for other functionality and applications.

■ **Real-time operating system.** SIMATIC IPCs come preloaded with the Microsoft Windows 7 Ultimate (32/64-bit) operating system and a five-language, multi-lingual user interface (MUI) to facilitate the globalization of applications. Also standard is the Windows Embedded Standard Real-Time Operating System (RTOS) – although Linux, QNX and Wind River VxWorks RTOSs are available upon request. Microsoft Windows provides compatibility with the widest number of applications in the world, while giving oil and gas producers access to the world's biggest community of developers.

■ **Wide range of form factors for deployment flexibility,** including rack, box and embedded IPC configurations with separate HMIs, as well as panel IPCs with 12-,15-, 19- and 22-inch touch-screen displays. (SIMATIC industrial thin-clients are available, too.)

What makes SIMATIC IPCs a special breed of PCs?

While readers now know the broad differences between IPCs and standard, office-grade PCs, it helps to go a bit deeper into those distinctions to understand how they can benefit oil and gas industry applications. Let's start with the two most obvious ones that we've already touched on: *built-in reliability and extreme ruggedness.* Consider:

■ **MTBF rates > 10 years.** IPCs are designed and engineered to provide continuous operating reliability with very high mean-time-to-failure (MTBF) rates – greater than 10 years. To achieve such levels of availability, Siemens does main circuit board and BIOS development in-house under its strict quality standards.

Solid-state components are used, such as hard drives, so SIMATIC IPCs have no moving parts. All models use their metal frames as heat sinks for cooling, eliminating the need for fans in some models – and further reducing possible points of failure. In addition, all IPC solder connections are tested via X-rays to ensure quality. IPCs endure continuous testing on vibration tables to validate that they can with stand the same after deployment.

■ **Extreme ruggedness.** Thermal stress testing subjects each assembled IPC to a 36-hour run-in test at maximum load and 104°F (40°C) ambient temperatures. This ensures that each IPC can operate in the extreme heat for which it is rated. In fact, two SIMATIC high-end IPC models are temperature-rated to 134°F (55°C). These temperatures can reflect the operating conditions of oil and gas applications, especially

An RTOS provides PC applications with the capability to execute an action or process within a defined time frame, usually milliseconds, which is considered "near-real-time." Standard PCs can execute PC functions like a mouse click or key stroke in "non-real-time" at speeds between 75 and 100 ms or slower, because that's the threshold of human perception. In other words, people won't notice a mouse click or key stroke done any faster. But industrial applications often need to execute much faster (< 50 ms) and in deterministic, fixed-precision timeframes, because a process requires it.

■ **Fail-safe systems.** For even greater reliability and control – especially for the sake of life-safety in hazardous environments – SIMATIC IPCs implement the PROFIsafe safety communications technology for distributed automation, similar to SIMATIC safety-rated PLCs.

PROFIsafe is a way for the IPC to monitor the proper operation of its own internal commands and detect errors as they occur. This can avoid costly production disruptions or, worse, the triggering of an undesirable event (like a valve release), which could have grave environmental consequences that endanger personnel or nearby communities. If the system detects an error, it then shuts down safely.

PROFIsafe is designed as a separate layer on top of an IPC's PROFINET and PROFIBUS communications layers to reduce the probability of data transmission errors. In effect, it provides a "fail-safe" system that complies with the globally recognized IEC 61508 safety standard and can be used in safety-rated applications up to Safety Integrity Level (SIL) 3. To achieve this, PROFIsafe uses error- and failure-detection mechanisms such as:
• Consecutive numbering
• Timeout monitoring
• Source/destination authentication
• Cyclic redundancy checking (CRC)

■ **Remote management, diagnostics and service.** With IPCs often deployed in distant oil and gas production or transmission applications, service calls can be expensive, while disruptions can be costly. The Intel CPUs that are the brains of every SIMATIC IPC have Intel's Active Management Technology (AMT) firmware installed. This enables a remote systems administrator with an Ethernet connection to manage – securely and via encrypted communications – all IPCs on a network, as well as to diagnose any problems and update BIOS and software. With an Internet connection, administrators can literally be anywhere in the world and yet be able to remotely restart an IPC and access its BIOS and all applications, as if the IPC was on their desktop. In addition, SIMATIC IPCs feature diagnostic utilities that can assess their components' operating conditions, similar to how PLCs can do the same (e.g., CPU temperature, cooling fan speeds and so forth).

■ **Layered "defense-in-depth" security.** According to the U.S. Department of Homeland Security, the energy sector is the #1 target of cyber attacks of all 16 critical industries tracked by its Industrial Control Systems Cyber Emergency Response Team (ICS-CERT). The number of attacks can be three times those on critical manufacturing facilities, the runner-up, and 30 times those on government facilities. Today's best practice approach

to cyber security is a layered, so-called defense-in-depth strategy. For this, SIMATIC IPCs can provide an important tier of protection through the installation of software firewalls, VPNs and strict user authentication policies. Antivirus software using deep-packet inspections of network traffic can guard against malware and alert administrators of cyber attacks.

■ **Robust developer resources.** As mentioned, one of an IPC's big advantages for the oil and gas industry is enabling more widely integrated operations via applications that combine PLC control logic with more enterprise-oriented PC-based applications. But to achieve these integrations and also to create custom applications, developers and integrators need a wide range of tools and resources to make software development and engineering cost-effective.

To help, the SIMATIC IPC portfolio includes an Open Developers Kit (ODK), with even more tools for customizing applications, integrating specialized hardware, connecting with enterprise business systems and interacting with higher-level languages such as Java, Visual Studio and C++. Developers can implement their applications either in Windows or in the RTOS. Examples include: ultra-fast algorithms used in closed-loop controllers and sorting processes; well-head performance data acquisition and analysis in SQL databases; and applications using the IPCs' serial interfaces to connect peripherals, like video cameras on offshore rigs, with centralized monitoring systems at onshore headquarters.

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Conclusion

As a capable and flexible high-performance alternative to PLCs, PC-based automation can help the oil and gas industry adopt integrated operations more widely across the full range of its value chain to lower costs and boost profitability. But purpose-built IPCs are needed. That's because office-grade PCs cannot withstand the rigors of general industrial environments, much less those of the oil and gas industry. While IPCs must be designed and engineered from the start with reliability and ruggedness in mind, performance does not have to be sacrificed. Siemens SIMATIC IPCs are examples of these kinds of devices, and their features can provide benchmarks to evaluate IPCs from other suppliers. To learn more about the full line of Siemens SIMATIC IPCs, readers are invited to visit: www.usa.siemens.com/IPC.