SIMATIC PC-based Automation with Intel® Core™ processor family

White Paper • March 2011

SIMATIC PC-based Automation

Answers for industry.
About this document:
This White Paper provides you with answers to the following questions:
- What is new in the 2010 Intel® Core™ processor family?
- How has Siemens implemented the new 2010 Intel Core processor family in SIMATIC IPC/PG?
- Which performance benefits result through the use of the new Intel Core processors in SIMATIC IPC/PG?

Note:
The information provided in this documentation contains merely general descriptions or performance characteristics, which in case of actual use, do not always apply as described or may change as a result of further development of the products. An obligation to provide the respective characteristics shall only exist if expressly agreed in the terms of contract.

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SIMATIC IPC/PG on the Internet
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1 Introduction

After the long dominance of single-core processors with ever higher clock frequencies, the great success of the Intel® Core™2 processor family heralded the triumph of multi-core systems, not least in industrial applications. Although "small" systems with only one processor core still have their place, it is increasingly important to have the processing power available to execute multiple program threads in parallel. Here, the integration of several tasks on an industrial PC enables significantly higher performance. For example, in addition to a software programmable logic controller (PLC), the industrial PC must process other tasks such as taking measurements via connected peripherals. At the same time, a visualization application running on the industrial PC demands high levels of computing performance to quickly update and represent the system and its many parameters. Another aim in industrial applications is to reduce the number of devices in the field, which saves procurement cost and space.

The need for higher industrial PC performance is driven by more demanding requirements such as: performing more precise measurements in the field of quality control; simultaneously archiving and visualizing measured data; and processing and evaluating image data quickly and accurately.

This white paper describes how the 2010 Intel Core processor family differentiates itself significantly from predecessors, including:

- New features of the 2010 Intel Core processor family
- How Intel processors are used in SIMATIC IPCs/PGs
- The benefits derived from the increase in performance.
2 What is the Intel® Core™ processor family?

2.1 Intel® Core™ micro architecture

The Intel® Core™ micro architecture is enhanced on a reliable and predictable timeline using a model designed to deliver ongoing innovation. Referred to as the “Tick-Tock model”, the release of a new architecture (Tock) is followed by a reduction of the associated processor structures by improving the manufacturing process (Tick). For example, the Intel Core 2 processor family was first produced on 65nm Intel® Process Technology (Tock), and later, the same micro architecture was refined and implemented on 45nm Intel process technology (Tick). Moving forward, the new Intel Core processor family uses a new micro architecture (Tock), and the manufacturing process advanced from 45nm to 32nm technology (Tick) at the beginning of 2010.

![Intel Core Microarchitecture Chart](image)

Intel's "Tick-Tock" model, delivering next-generation of silicon technology as well as new processor micro architecture, year after year.

In general, new silicon process technology employs smaller structures (e.g., transistors, conductors) that lower power consumption and power loss (e.g., Thermal Design Power - TDP), thereby reducing the waste heat that must be drawn away from the system.

The Intel Core processor family is multi-core and has three levels of cache, one more than its predecessor with two levels of cache. Each core has a 64 KB L1 cache for storing data and instructions ready for execution. Additionally, there is a 256 KB L2 cache, also used for data and execution instructions. Some of the processor models also have up to 8 MB of L3 cache, which stores data for all of the cores. Since the caches reside on the processor die, they can be addressed and read out much faster than the main memory. This cache architecture dramatically reduces the wait times for data and instructions, thereby boosting the efficiency of the processor cores.

One of the significant new features of Intel Core micro architecture is the Intel® QuickPath Interconnect (Intel® QPI). This high-speed bus is used to connect the processor to the rest of the system components, including system memory, various I/O devices and other Intel processors. With up to 25.6 gigabytes per second (GB/s), Intel QPI offers double the bandwidth of the previously used front side bus (FSB), which connected the processor to the Northbridge of the chipset.
Along with the introduction of the new Intel Core micro architecture, the previous system setup for Intel systems, consisting of Northbridge and Southbridge, was revised and redesigned:

### Three-level Intel® Core™2 architecture

- **Processor**
  - FSB
  - Intel 4 Express chipset (Northbridge)
  - ICH 10 (Southbridge)
  - DMI

### Two-level 2010 Intel® Core™ architecture

- **Processor**
  - PCIe* Graphics
  - IMC
  - DDR3

- **PCH**
  - Direct Media Interface
  - Intel® Flexible Display Interface (Intel® FDI)
  - Display
  - ME
  - I/O

Explanation of terms:
- iGFX/GFX: Integrated Graphics
- IMC: Integrated Memory Controller
- ME: Management Engine (permits access to Intel® Active Management Technology (Intel® AMT) functions, for example)
- I/O: Input/output interfaces such as USB, SATA, etc.

Functions that were previously performed by the Northbridge were integrated into the main processor, including:
- Connection of the main memory to the system
- Data traffic with the graphics card (PCIe x16 interface)

The new platform controller hub (PCH) remains on the mainboard and performs control functions. It integrates several tasks of the Northbridge and the previous Southbridge, such as:
- the data traffic with the drives
- the data traffic with interfaces, e.g. USB
- the connection of the PCI and PCIe expansion slots
- control of the screen interfaces, e.g., DVI

The communication between processor and mainboard chipset is implemented via a serial connection, called DMI (Direct Media Interface). This data link supports a data transfer rate of 2 GB/s. The monitor signals are transferred from the processor to the PCH via their own interface, the Intel® Flexible Display Interface (Intel® FDI), and thus do not place a load on the DMI.

In the Intel Core processor family, the controller for connecting the main memory is integrated on the processor die and connected to the main processor via Intel QPI. This integration results in a significant performance gain as the main memory must no longer be
addressed across the front side bus, which previously often slowed down the exchange of data.

The Mobile 32-nm processors based on the 2010 Intel Core micro architecture are built with a two-die multi-chip package, where the processor on the left side of the picture is alongside the combined graphics and memory controller chip on the right side. The integrated graphics unit is called Intel® HD Graphics (see chapter 2.3.3).

The Intel Core processor family supports DDR3 memory (see chapter 3.2) and also provides other interesting performance-enhancing features such as Intel® Turbo Boost and Intel® Hyper-Threading Technology (Intel® HT Technology) (see chapter 2.3).

The current version 6.0 of the Intel® Active Management Technology (Intel® AMT) is also supported by the Intel Core processor family, which is described in chapter Fehler! Verweisquelle konnte nicht gefunden werden..
2.2 Intel® Core™ processor family – the performance classes

While the performance of processors based on prior Intel Core micro architectures was determined by the number of cores and the clock speed, the new 2010 Intel Core processors take a different path. Performance is no longer determined using the above criteria, but through performance classes. There are currently three performance classes:

- Intel® Core™ i3 processor:
  These processors are considered entry-level. They have two physical cores, and with Intel HT technology activated, four threads can be processed simultaneously. Some performance features are absent or deemphasized in the Intel Core i3 processors, such as the lack of Intel Turbo Boost Technology and the L3 cache size, 3 MB maximum, which is at the lower end of the memory options.

- Intel® Core™ i5 processor:
  These are the mid-range models of the Intel Core processor family and cover a broad spectrum of functions and design variations. Depending on the architecture, they offer four or two physical cores, as well as Intel HT Technology, which increases the number of logical cores. Performance-enhancing Intel Turbo Boost Technology is available and the L3 cache capacity ranges from 3 MB to 8 MB.

- Intel® Core™ i7 processor:
  These are the highest-performance processors of the Intel Core processor family and they have the highest clock speeds. Intel HT Technology and Intel Turbo Boost Technology are standard for all these processors. Some models support up to 12 logical cores, which an operating system can use to distribute software threads. The memory capacity of the L3 cache ranges from 4 MB to 8 MB.

For further classification within each performance class, each processor is also provided with a 3-digit numerical identifier representing the "hierarchy" within a performance class. For example, an Intel® Core™ i7-940 processor has more computing performance than an Intel® Core™ i7-920 processor.

In addition, the letters after the numerical identifier provide information on specific properties or areas of application of the processors. Mobile processors are indicated with an "M", as with the Intel® Core™ i7-620M. There are other abbreviations such as "U" ("Ultra high energy efficient", TDP ≤ 11.9 W), "L" ("Highly energy efficient", TDP 12-19 W) and "E" for long-term available embedded processors.

2.3 Intel® Hyper-Threading technology, Intel® Turbo Boost technology, and Intel® HD Graphics with Dynamic Frequency

2.3.1 Intel® Hyper-Threading technology

The Intel® Hyper-Threading Technology (Intel® HT), originally deployed in Intel® Pentium™ 4 processors, is implemented by the Intel® Core™ processor family. All processors used in SIMATIC IPC/PG support this feature, which provides each physical processor core with another parallel virtual processor core. Additional program components can be executed in parallel on this virtual core if the processor capacity is not fully utilized by the first thread.

In an Intel Core processor with two physical cores, for example, a Windows operating system displays four available logical cores in the Windows Task Manager. The performance gain due to Intel HT Technology depends on the programs to be run and can be as high as 30 percent. Still, one core with Intel HT Technology enabled does not achieve the same performance as two real physical cores. Additionally, the overall performance depends on factors such as the degree of parallelization of the programs being processed, dependencies
of individual threads on one another, total number of open (running) programs and the distribution of threads by the operating system.

In a quad-core processor without Intel® Hyper-Threading Technology (left image), only four threads can be processed in parallel. Ideally, a quad-core processor with Hyper-Threading (right image) can process eight threads in parallel.

The following image shows the performance benefits of multi-core systems with Intel HT Technology. Starting with a system with only a single processor core, another core is added, followed by the activation of Intel HT Technology. The image shows the time savings resulting from adding a physical core and two virtual cores, which in turn, increases the number of threads that can be processed simultaneously.

The use of real-time operating systems with Intel HT Technology activated may cause adverse affects in the real-time behavior. For more information and guidance, see the installation instructions for the operating system.
2.3.2 Intel® Turbo Boost Technology

The processors of the Intel Core processor family offer advanced power management, called Intel Turbo Boost Technology. For most processors in this family, this allows an automatic load-controlled increase in clock speed of one or more processor cores.

Technical requirements:
- Always activated or may be activated in BIOS
- Supported by the processor

The activation of the feature during normal operation is dependent on various factors, including:
- Thermal and electrical limits of the processor are not exceeded
- Number of active cores – active cores can be clocked higher when there are fewer cores active. To take full advantage of Intel Turbo Boost technology, it must be possible to switch inactive cores to "sleep mode" (C3 or C6).
- Anticipated required performance

To increase performance, the cores of an Intel Core processor can be sped up by a specific multiplier of the reference clock speed (133 MHz). The chipset ensures that the thermal and electrical limits of the processor are not exceeded. The reference clock speed multiplied by a multiplier also determines the individual processor speed (e.g. 133 MHz x 18 = 2.4 GHz) and the clock speed for Intel QuickPath Interconnect (max. 3.2 GHz with multiplier 24).

Example:
If all the cores of a processor are equally utilized, they are sped up by 133 MHz as long as the processor is able to operate within its limits. If a single-threaded program is running, only one core is boosted (by the processor-dependent multiplier of the reference clock speed), while the other cores are put into sleep mode.

![Without Intel® Turbo Boost technology (older generations)](image1)

![With Intel® Turbo Boost technology](image2)

Single-threaded workload < TDP  
Highly-threaded workload < TDP

The Windows 7 operating system provides an Intel Turbo Boost Technology sidebar gadget that simply displays the current clock speed of the processor (see right-hand side). Here, the processor type appears (in the example on the right, an Intel Core i5 processor) along with its nominal clock speed (2.40 GHz) and the present clock speed with Intel Turbo Boost technology enabled (2.79 GHz).

In SIMATIC IPC, Intel Turbo Boost Technology and the possible
sleep states for inactive cores can be activated or deactivated in the BIOS settings. The deactivation of the Intel Turbo Boost Technology can be necessary, for example, when using a real-time operating system. To ensure that the strict real-time requirements are met, measurable and deterministic processor performance must be available at all times.

2.3.3 Intel® HD Graphics and Dynamic Frequency

In the current 2010 Mobile Intel Core processor family, a graphics chip is placed in the two-die multi-chip package and is referred to as the "Intel® Core™ processor family with integrated graphics". The basic structure of an Intel Core processor package with integrated graphics can be seen in the picture on the right. The upper, smaller chip is the processor, manufactured using 32 nm silicon technology. Below is the graphics chip, which is manufactured with 45 nm silicon technology. The close proximity of the two chips helps maximize performance since the signals have a relatively short distance to travel. The connection via Intel QPI also increases the data throughput between the processor and graphics unit. These graphics chips, called Intel® HD Graphics, are a further development of the widely-used Intel® Graphics Media Accelerator (GMA) onboard graphics. The new graphics capability is highly optimized, delivering exceptional 3-D performance and vivid display of operating system user interfaces such as Windows 7 with Aero.

The integrated graphics chip of the new 2010 Mobile Intel Core processors offers a feature corresponding to Intel Turbo Boost Technology to increase graphics performance. Called Intel® HD Graphics with Dynamic Frequency, the feature allows the graphics chip to be overclocked according to the same rules as individual processor cores. The overclocking of the graphics processor (GFX) is implemented independently of the Intel Turbo Boost Technology. Further clarifying, all 2010 Mobile Intel Core processors have this feature. The graphics chip can only be overclocked when the power consumption and the temperature of the processor die do not exceed the specified limits.

The new integrated graphic chipsets offer up to 5x better graphics performance than the Intel® GMA900 and GMA950 previously used in SIMATIC IPCs.
2.4 Operating systems

As a rule, all processors in the Intel Core processor family can run with a 32-bit operating system without any problems. However, the restricted address space and the resulting maximum practical memory configuration of 4 GB should be considered – a 32-bit operating system cannot address more memory. Intel Core processors also support 64-bit operating systems, which is certainly a sensible choice to implement the maximum memory configuration. Because features, such as Intel HT Technology and Intel Turbo Boost Technology, are anchored in hardware, they can generally be used with any operating system.

Although multiple-core systems run without any problems on most operating systems, more modern operating systems tend to be better optimized for them. For example, Windows 7 is more effective at distributing individual program threads to the available threads than Windows XP Professional. Non-Windows operating systems, such as Linux, run without problems on multiple-core systems and take advantage of the benefits of thread distribution wherever possible. It should be noted that for some operating systems, such as real-time operating systems, specific properties of the Intel Core processor family must be deactivated.

2.5 Virtualization

Virtualization means that several operating systems can run simultaneously on a single computer. The Intel Core micro architecture supports Intel® Virtualization Technology (Intel® VT)\(^1\), a technology that provides basic optimization for virtual machines and thus allows these systems to deliver higher performance. The higher-end Intel Core i5 processors and Intel Core i7 processors both also support Intel VT-d\(^2\). This accelerates a virtual machine’s direct access to hardware components.

2.5.1 Software components for virtualization

Additional software components are required for implementing virtualization solutions:

- **Hypervisor**
  The hypervisor forms the basis for a computing system with virtualization. It manages a PC’s hardware resources, e.g., memory access, and addresses mass storage media such as SSD or HDD. Some operating systems, such as Windows, provide hypervisors, or they can be acquired from independent software vendors.

- **Virtual Machine Monitor (VMM)**
  The VMM provides an environment for the emulated operating system in which the individual virtual machines can run. It emulates standard interfaces, such as Ethernet and USB, and provides the virtual machine with a standard driver for these interfaces, regardless of which controller is actually physically used.

- **Virtual Machine (VM)**
  A virtual machine represents an encapsulated environment, comprising an emulated operating system and the applications launched from it. A virtual machine can be saved as a file. In principle, an unlimited number of VMs can be started and run simultaneously. The limiting factor, however, is the computer’s performance and system memory. Because 64-bit operating systems allow the addressing of more than 4 GB of memory, their use as host OS or hypervisor can bring a significant performance boost when multiple virtual machines are instantiated in parallel.

\(^1\) Also known as "Vanderpool"
2.5.2 Types of virtualization solutions

There are three types of virtualization solutions.

**Full virtualization:**

In full virtualization, an operating system is emulated with all standard drivers. The advantage of this approach is the relatively simple operability and availability of the VMM and the VM. A variety of solutions, including VMware, implement fast virtual machines that run various operating systems and can be used to test new programs. It is worth noting special hardware, such as PROFIBUS or PROFINET interfaces, are generally not supported by these VMMs, meaning that no access to them is possible.

**Paravirtualization:**

In paravirtualization, the hypervisor takes on the tasks of a host operating system and monitors all hardware access and resource distribution. Here, special hardware can be integrated into a virtual environment, although special drivers are needed for the hypervisor and the guest operating system in the virtual machine. Several solutions, such as Hyper-V, are available on the market. However, drivers for special hardware must usually be custom programmed.
Hardware-supported virtualization:

Hardware-supported virtualization allows direct access from a virtual machine to existing hardware with the drivers installed in the VM. This is made possible by Intel® VT-d and VT-d2. This approach gives real-time operating systems direct hardware access, while applications, like visualization, run simultaneously on other operating systems, such as Windows, located in VMs.

One restriction is the relevant hypervisor must support Intel® VT-d. If this technology is expanded or new functions are implemented (e.g. in the current version of Intel® VT-d2), the hypervisor must also be adapted. In this area, there is a great deal of movement in the market and no standard has yet been established. In most instances, proprietary solutions for particular use cases have emerged.

2.5.3 Outlook

It is expected that virtualization technology will radically change existing and future IT infrastructures. Virtualization provides users with cost-effective total solutions, as in integrating control and visualization into a single system. Solutions are possible, in which one processor core with integrated real-time control is active and thus ready to run at any time, while the other core on which applications are running, such as visualization software, can be rebooted, if needed.

In another scenario, the hypervisor can ensure the RTOS\(^2\) running a control application has the right amount of system power by limiting or expanding the computing resources available to less time-critical applications, like visualization running on a guest OS. In this way, visualization and control can make the best use of resources on a powerful PC, with the higher priority given to the control application by the hypervisor.

Virtualization is also used in workplaces where users do not need their own computers, but instead, access a server via a network, which starts a dedicated VM for each user. This lowers a company’s IT costs since they can supply end users with less expensive devices, reduce cabling, deploy fewer accessories, etc. Furthermore, the available computing power can be better distributed among individual users. In typical word processing tasks on a desktop PC today, much of the computer capacity goes to waste. In contrast, a hypervisor can assign the computing power as needed. If program errors occur, a simple restart of the virtual machine usually helps avoid time-consuming and costly calls to IT managers or help centers.

Another benefit is programs do not need to be adapted when a hardware update is desired or necessary – at least not as long as there are virtualization solutions available for the new hardware that allow the old operating system to be emulated. Such systems are even less vulnerable to computer viruses because if system files are infected, the viruses disappear after a restart of the virtual OS.

Virtualization is also used by programmers creating a new tool for an application. The development environment runs on an OS on one core while the OS with the application program runs on another core, enabling the developer to test the new software module immediately.

\(^2\) Real-time operating system
2.6 Remote Management with SIMATIC IPCs

2.6.1 Remote Management via Intel® Active Management Technology (Intel® AMT) – Application Options

Remote maintenance options via Intel AMT have been widely employed in business client applications for many years. Accompanying the introduction of the 2010 Intel Core technology, Intel also launched its AMT 6.0 version. The supported new functions such as KVM redirection (see next chapter) now also open up interesting application options for machine and system manufacturers as well as operating and service staff in the industrial sector. This is why Intel AMT is now also implemented in SIMATIC IPCs featuring the 2010 Intel Core technology.

- Central service
  AMT clients can be easily accessed remotely without additional hardware. The connection can either be established in an unprotected manner, e.g. via exclusively company-internal networks, or via a protected HTTPS or TLS connection from anywhere around the globe.

- Remote diagnostics and access without on-site works
  Remote management facilitates the rectification of software faults without having to be on site. Intel AMT can be utilized independently of the operating system thanks to its integration in the hardware. Also systems with frozen applications or crashed operating systems can be accessed. In addition, BIOS and program updates can be installed via remote access and the PC can be restarted for the installation's completion if required.
- **Resource management**
  SIMATIC IPCs left running unnecessarily or after production stops / on weekends can be shut down by means of remote access via a control station or a central service point. This results in reduced power consumption and corresponding costs. Furthermore, PCs can be switched on centrally, e.g. for update installation. As this can also be done outside regular production periods, the respective machine's or system's efficiency is not impaired by downtimes.

Application example of simultaneous remote access to four AMT-capable clients via SIMATIC IPC Remote Manager:
2.6.2 Intel® Active Management Technology (Intel® AMT) – Basics

The Mobile Intel® QM 57 Express chipset with the Intel Core i5 and Core i7 processors as well as the Intel® 82577LM network controller support Intel® vPro™, of which the Intel Active Management Technology (Intel AMT) forms part, on the hardware side.

The PC via which other PCs are accessed is referred to as administrator. The administrator itself need not feature any integrated AMT functions. The AMT clients represent the PCs which are accessed. As opposed to the administrator, these PCs have to feature integrated Intel AMT. In order to be accessed, the PCs have to be networked via a TCP/IP connection and supplied with power. The system-tested SIMATIC IPC Remote Manager software is available for utilization of the Intel AMT functions with SIMATIC IPCs.

Possible network layout for remote management: Networked SIMATIC IPCs with Intel AMT can be accessed via a rack PC SIMATIC IPC547C, which does not feature any Intel AMT functions itself, by means of SIMATIC IPC Remote Manager and / or web browser.

The image below shows the SIMATIC IPC Remote Manager's toolbar with its basic control elements:

- KVM connection establishment
- ISO image integration (IDE redirection)
- Power functions
SIMATIC IPCs feature two onboard Ethernet interfaces, each with a separate controller. One of these controllers can be configured for utilization with Intel AMT. Using Intel AMT is also possible, if both Ethernet ports are connected to improve redundancy (“Teaming”).

With SIMATIC IPCs, the Ethernet controller suitable for AMT features an "M" in its designation. The green circle shows the AMT access-suitable "Intel® 82577LM" of a Rack PC SIMATIC IPC647C in the network connections view under Microsoft Windows XP.

For safety reasons, Intel AMT is disabled in the SIMATIC IPC's delivery state and has to be enabled in BIOS. Access to the Intel® Management Engine (Intel® ME) is subsequently enabled. Here, further basic settings are required, e.g. network configuration for AMT access and safe password creation. The setup process is described in the operating instructions of the Intel AMT-capable SIMATIC IPCs and of the SIMATIC IPC Remote Manager.

The table below provides an overview of the implementation of Intel AMT with SIMATIC IPCs:

<table>
<thead>
<tr>
<th>SIMATIC</th>
<th>Applicability as AMT client</th>
<th>Applicability as administrator PC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rack PC</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPC647C</td>
<td>Processors: Intel Core i5 or Core i7</td>
<td>• With any operating system and web browser</td>
</tr>
<tr>
<td>IPC847C</td>
<td>BIOS version: V15.01.05 or higher</td>
<td>• With Windows operating systems and SIMATIC IPC Remote Manager</td>
</tr>
<tr>
<td>IPC547C</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td><strong>Box PC</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPC627C</td>
<td>Processors: Intel Core i7</td>
<td></td>
</tr>
<tr>
<td>IPC827C</td>
<td>BIOS version: V15.02.05 or higher</td>
<td></td>
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<tr>
<td><strong>Panel PC</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HMI IPC677C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HMI IPC577C</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>HMI IPC477C</td>
<td>No</td>
<td></td>
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<tr>
<td><strong>Microbox PC</strong></td>
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<tr>
<td>IPC427C</td>
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<td></td>
</tr>
<tr>
<td><strong>Field PG</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field PG M2 / M3</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>
Remote management utilizes numerous Intel AMT functions. Amongst others, this comprises:

- **Keyboard video mouse redirection (KVM redirection)**
  This function facilitates the redirection of an AMT client's keyboard-video-mouse signal to or from an administrator PC via a remote connection, which enables the administrator to access the PC without additional hardware. Depending on the configuration in the AMT settings, access to the PC can either be realized directly or only after permission by the local user. In the latter case, the screen of the AMT client shows an information box with a code which has to be dictated to the administrator by the client user. Only after this process is access permitted. In any case, access by an administrator is indicated to the AMT client by a red border and blinking icon on the screen.
  The operation of multiple PCs in a control cabinet via KVM redirection based on Intel AMT represents a further application. Up to now, the PCs were operated by means of a KVM switch and the corresponding monitor and USB cables. The KVM switch and cables can be economized when configuring one PC as administrator and the other PCs as clients.

- **Remote power control**
  This function facilitates PC switch-off and switch-on from standby via remote access. Also remote "hard" shutdown or reset of the PC supported. When using the power OFF and reset functions, potential application and operating system damage in case of improper system shutdown has to be taken into account.

- **Remote reboot**
  This function facilitates the proper shutdown and subsequent reboot of an AMT-capable SIMATIC IPC by means of remote access via the SIMATIC IPC Remote Manager. This for example supports the remote implementation and completion of program installations which require a PC restart.

- **Disk redirection (IDE-R)**
  This function facilitates the setup of an ISO image accessible on the administrator PC as drive on an AMT client. The AMT client can then access this drive for reading routines and can for example boot via this drive or start tools programs or program updates installed on this drive.

- **Integrated web server**
  This function facilitates access to an AMT client's integrated web server via any Internet browser. Amongst others, the browser displays system and status information of the SIMATIC IPC and supports basic network settings as well as routines such as power on / off and reset. A controlled AMT client shutdown via web browser is not possible. Communication can be realized via a non-protected HTTP or via a protected HTTPS connection.
3 Memory

3.1 Memory configuration

The maximum possible memory configuration is determined in hardware by the memory controller on the processor die and the number of available memory banks. While the theoretically possible upper memory configuration limit for 64-bit systems is in the exabyte range \(10^{18}\) bytes, it is restricted in practice by the current state of technology. The memory controller of the Intel Core processors in SIMATIC IPC/PG can control two memory banks in dual-channel mode (see chapter 3.3) with a maximum possible memory configuration of 8 GB.

3.2 DDR3 SDRAM

DDR3 is the memory generation succeeding DDR2, and it is already used as a modern memory technology in the current SIMATIC IPCs/PGs. The new Intel Core micro architecture supports only DDR3 memory modules. The resulting benefits for SIMATIC IPC/PG include: better performance, greater interference immunity, and lower power loss with correspondingly lower heat generation, since DDR3 requires only 1.5 V instead of 1.8 V with DDR2.

3.2.1 Explanation of terms: DDR3 SDRAM

Memory modules consist of individual memory chips in which data is stored line-by-line. Memory chips come in many sizes, with lines normally 64 bits in length. Taken together, the memory chips installed on a module determine its memory capacity.

The term DDR3-SDRAM consists of two partial terms:

- SDRAM is short for Synchronous Dynamic Random Access Memory. Random access memory describes memory that may be written to any number of times. If the power supply is switched off, the RAM blocks normally lose their stored values, also referred to as "volatile". The term "dynamic" comes from the technology with which the contents of memory must be refreshed: Here, the contents of a memory chip must be constantly rewritten, line-for-line, every few milliseconds. The opposite of this is "static", which describes memory that retains its value without refreshment when power is applied. Finally, "synchronous" means that the memory clock is synchronized with the system clock.

- DDR stands for double data rate. When memory chips were introduced, their values could be read or written line-by-line, once per cycle, meaning that 64 bits of data could be transferred per cycle. These memory modules were designated SDR (single data rate). DDR doubles the data transmission rate by transmitting data twice per clock cycle (double data rate). This is accomplished by using both the rising and falling edges of a clock cycle. As before, for technical reasons, control data, such as the "question" of the content of a particular memory area, can be transferred only once per cycle. To achieve the higher data rate, the memory controller reads out only the desired line and the subsequent line. DDR2 increases this transmission rate by a factor of two to four times. DDR3

\(^3\) Changed BIOS settings, for example, are saved in static RAM (SRAM). As long as the mainboard battery provides power this data is retained even after the computer is switched off.

\(^4\) Not to be confused: SDR and SDRAM describe different matters. SDR describes the type of data transfer and SDRAM describes the memory structure. There is therefore both, SDR-SDRAM and DDR-SDRAM.
ultimately improves performance further by another factor of two so that eight times the data quantity of a SDR-SDRAM memory module is achieved. These, however, are theoretical values. If, for example, only the requested values of a memory line are needed, the provision of the following lines is pointless. The high data transfer volume can only be usefully exploited if large amounts of data are needed from consecutive lines.

3.2.2 Example for the calculation of memory parameters

Parameters used in the context of memory chips are best explained using an example:

- SDR-SDRAM, for example, is addressed at a clock speed of 133 MHz (SDR-133). SDRAM modules generally have a 64-bit interface so that the following data volume can be transferred per second:
  \[(64 \text{ bit} \times 133 \text{ MHz})/8 \approx 1 \text{ GB/s}\]

- DDR doubles this, as described in section 3.2.1:
  \[(2 \times 64 \text{ bit} \times 133 \text{ MHz})/8 \approx 2.1 \text{ GB/s}\]
  The clock speed used to address the memory remains 133 MHz, but the speed appears to have doubled in terms of data transfer performance, which is why a chip of this kind is designated "DDR-266" with 266 MHz effective clock speed. A complete memory module is designated as follows: PC-2100\(^5\)

- DDR2 doubles this again:
  \[(4 \times 64 \text{ bit} \times 133 \text{ MHz})/8 \approx 4.2 \text{ GB/s}\]
  Once again, the calculation of the effective clock speed: \(4 \times 133 \text{ MHz} \approx 533 \text{ MHz}\).
  The memory chips are thus designated DDR2-533.
  A complete memory module is designated as follows: PC2-4200

- And finally DDR3:
  \[(8 \times 64 \text{ bit} \times 133 \text{ MHz})/8 \approx 8.5 \text{ GB/s}\]
  Effective clock speed: \(8 \times 133 \text{ MHz} \approx 1066 \text{ MHz}\)
  This chip is therefore known as DDR3-1066
  The memory module: PC3-8500

The maximum clock speed with which a memory module can be addressed depends on the mainboard chipset. Using the above formulas, it is possible to calculate the maximum transfer performance and the clock speed of a memory chip.

One of the fastest memory chips presently available is designated DDR3-1600. The clock speed with which a memory chip is addressed is determined as follows:

- \(1600 \text{ MHz}/8 = 200 \text{ MHz}\)
- The bandwidth is thus: \((8 \times 64 \text{ bit} \times 200 \text{ MHz})/8 \approx 12.8 \text{ GB/s}\)
- A corresponding memory module is designated PC3-12800

\(^5\) The number of bytes is one-eighth the number of bits.
\(^6\) Derived from 2.1 GB
3.3 Dual channel

If a memory module is placed in each of the available memory banks, the memory controller can access these simultaneously, theoretically doubling the amount of data that can be transferred.

A further example: The SIMATIC IPC/PG’s memory controller can control two databases equipped with DDR3-800 memory modules with 64 bits each; i.e., it can access them in dual-channel mode. The maximum memory configuration is 8 GB, so it is best to use dual-channel mode with two 4 GB memory modules. The theoretically possible data transfer rate is:

\[ 8 \times 64 \text{ bit} \times 2 \times 100 \text{ MHz/8} \approx 12.8 \text{ GB/s} \]

If instead only one bank was equipped with an 8 GB module, the data transfer rate would be only 6.4 GB/s.

3.4 Types of construction

Memory modules are offered in various designs. The best-known are DIMM and SO-DIMM modules:

- DIMM modules (dual inline memory modules) are elongated memory modules and carry different signals on the contacts on both sides. They are best known from desktop computers.
- SO-DIMM modules (small outline DIMM) are the DIMM's "little brother" and are therefore used mostly in laptops and netbooks.

3.5 ECC

ECC stands for "error correction code" and designates an error detection and correction procedure. Errors are detected and corrected by calculating and storing checksums for the 64 bits in a memory line. Additional memory chips must therefore be present on the memory module in order to store the checksum. Using the checksum, a single-bit error can be corrected and a 2-bit error detected. Detected errors are logged in a specific area of the BIOS (e.g., DMI data) and can be read out by appropriate programs. ECC increases the MTBF of a memory module in comparison to one without error correction by a factor of about 40.

ECC memory modules fit without modification in normal memory banks, but compared to identically constructed modules without ECC, they contain additional memory chips and data lines to accommodate the checksums of the "normal" main memory data. The checksums are not stored only on the additional chips but distributed across the memory chips. ECC is used in cases when an error in the contents of memory could have particularly serious consequences for people and the environment. Its use is mandatory, for example, in specific systems in power plants and medical technology.

ECC is generally also a good idea in applications where memory contents remain in the main memory for a long time until they are accessed. Server systems that are very rarely switched off are one example of this.
## 4 SIMATIC IPC/PG with 2010 Intel® Core™ Technology

### 4.1 Overview

New 2010 Mobile Intel Core processors with 32 nm manufacturing process, which are included in Intel's embedded roadmap and thus have 7-year extended lifecycle support, are used in all new SIMATIC IPCs/PGs.

<table>
<thead>
<tr>
<th>Processor name</th>
<th>Processor speed / with TB(^7)</th>
<th>Speed graphic / with DF(^8)</th>
<th>Cores/threads</th>
<th>Chipset (PCH)</th>
<th>TDP</th>
<th>Intel® VT</th>
<th>ECC</th>
<th>Intel® AMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rack PC IPC647C (2 HU) and IPC847C (4 HU)</td>
<td>Intel® Core™ i3-330E 2.13 GHz / n.a.</td>
<td>500 MHz / 667 MHz</td>
<td>2/4</td>
<td>Mobile Intel® QM 57 Express</td>
<td>35 W</td>
<td>VT-x</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Intel® Core™ i5-520E 2.40 GHz / 2.93 GHz</td>
<td>500 MHz / 766 MHz</td>
<td></td>
<td></td>
<td></td>
<td>VT-x / VT-d2</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Intel® Core™ i7-610E 2.53 GHz / 3.2 GHz</td>
<td>500 MHz / 766 MHz</td>
<td></td>
<td></td>
<td></td>
<td>VT-x / VT-d2</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Box PC IPC627C and Panel PC HMI IPC677C</td>
<td>Intel® Core™ i3-330E 2.13 GHz / n.a.</td>
<td>500 MHz / 667 MHz</td>
<td>2/4</td>
<td>Mobile Intel® QM 57 Express</td>
<td>35 W</td>
<td>VT-x</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Intel® Core™ i7-610E 2.53 GHz / 3.2 GHz</td>
<td>500 MHz / 766 MHz</td>
<td></td>
<td></td>
<td></td>
<td>VT-x / VT-d2</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

\(^7\) Clock frequency of the processor / maximum possible clock frequency of the processor with active Intel® Turbo Boost technology

\(^8\) Clock frequency of the graphic chip / maximum possible clock frequency of the graphic chip with Dynamic Frequency
<table>
<thead>
<tr>
<th>Field PG M3</th>
<th>Processor name</th>
<th>Speed / with TB</th>
<th>Speed graphic / with DF</th>
<th>Cores/threads</th>
<th>Chipset (PCH)</th>
<th>TDP</th>
<th>Intel® VT</th>
<th>ECC</th>
<th>Intel® AMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel® Core™ i5-520M (embedded option)</td>
<td>2.4 GHz / 2.93 GHz</td>
<td>500 MHz / 766 MHz</td>
<td>2/4</td>
<td>Mobile Intel® QM 57 Express</td>
<td>35 W</td>
<td>VT-x / VT-d2</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>
4.2 Benchmark results

4.2.1 Increase of SIMATIC Rack PC performance

The figure shows the performance increase of the SIMATIC IPC647C and IPC847C Rack PC versions through the use of the new Intel® Core™ processor family compared to the previous Intel® Core™ 2 technology. This results in several possibilities. For applications where the performance of the best processor of the “B” units was already sufficient, it is thus possible to switch to the entry-level processor of the “C” generation costing up to 19% less. Demanding applications, such as high-end image processing, benefit from a performance increase of 55% compared to the previous platform with Intel® Core™ 2 Duo processor and the up to 5x better graphics performance of the integrated graphics unit. In general, the Rack PCs are suitable for measuring, testing, open-loop and closed-loop control, e.g. with the WinAC RTX software PLC for industrial server applications, e.g. as a client server with WinCC and for process visualization.
4.2.2 Increase in SIMATIC Box PC / Panel PC performance

The Box PC and the Panel PC, which is based on it, also benefit from a significant performance boost through the use of Intel® Core™ architecture. The high data processing speed makes the IPCs ideal for use in power-hungry machine-level applications such as measuring, testing, open-loop and closed-loop controlling, e.g. with WinAC RTX and WinAC RTX F (failsafe) software PLCs as well as operator control and visualization, e.g. with WinCC flexible where these industrial PCs benefit from the up to 5x higher performance of the integrated graphics unit. Thanks to its high performance it is particularly suitable for combined tasks such as simultaneous control, visualization and data processing.
4.2.3 Performance increase with SIMATIC Field PG

It was also possible to achieve a significant performance boost of up to 74% with the SIMATIC Field PG by using Intel® Core™ technology. Together with the extensive automation interfaces and the pre-installed SIMATIC software the SIMATIC Field PG is optimally designed for engineering, commissioning, service and maintenance. High-resolution displays and the proven carrying handle offer very good ergonomics. A battery life of more than 3 hours ensures the high mobility of the SIMATIC Field PG.
4.2.4 SIMATIC WinAC RTX (F) 2010 software PLC on SIMATIC IPC with Intel® Core™ processors

In the industrial environment it is not only the maximum achievable performance that plays a role but a "minimum" promised performance is also needed to ensure the predictable behavior of a system.

If the SIMATIC WinAC RTX 2010 software PLC and the failsafe version SIMATIC WinAC RTX F are used with a SIMATIC IPC, a system can be implemented in which it can be ensured that predictable performance is available for both the SIMATIC WinAC RTX (F) and for the Windows component.

SIMATIC IPCs can be used without limitation with the SIMATIC WinAC software PLC. However, the following conditions must be observed:

- **Intel Turbo Boost Technology:**
  Intel Turbo Boost technology adversely affects the real-time behavior of WinAC RTX. It must therefore always be deactivated.

- **Intel Hyper-Threading Technology:**
  The Intel HT Technology can adversely affect the real-time capability of WinAC RTX especially in case of a heavy load due to Windows programs. For applications with high real-time demands especially in isochronous mode it is recommended that the Intel HT Technology be deactivated.

In SIMATIC IPC both technologies can be directly deactivated in BIOS.

SIMATIC WinAC RTX (F) supports only "dedicated mode" on SIMATIC IPCs with multi-core systems in which the real-time extension of WinAC RTX reserves a complete core of the processor by default. This one core remains invisible to the Windows operating system and is therefore not available. With SIMATIC WinAC installed on a SIMATIC IPC with Intel Core i5 processor and enabled Intel HT Technology there are still three cores that may therefore be used by the operating system.
5 Conclusion

Soon after it was launched by Intel, Siemens added the new 2010 Intel Core micro architecture to its SIMATIC IPCs. This gives users the highest performance and state-of-the-art technology. Users have the choice between different designs such as Box, Rack or Panel PC and therefore have greater flexibility in planning new systems or extending existing ones. OEMs and system designers can easily upgrade existing plants, machines and systems to implement new features with devices that are consistently installation-compatible. New designs benefit from the start from the performance capability and the new features of the Intel Core micro architecture.

As it has done in the past to ensure proven long-term availability, Siemens installed only the long-term available processors from the Intel embedded roadmap. With the new C-generation with Intel Core processors Siemens remains true to its concept that customers can configure and scale their devices individually. They therefore only pay for what they really need and can adapt the devices to their needs. And if the standard devices don't quite meet their needs the customization experts can make almost any wish a reality.

The optimal integration in automation solutions from Siemens (TIA) reduces engineering effort. This is ensured by extensive system tests with SIMATIC software and hardware such as SIMATIC WinAC, WinCC, WinCC flexible and SIMATIC NET. Numerous functions matched to each other such as PROFIBUS and PROFINET onboard (saves slots), the retentive memory of the Box and Panel PCs (for backup of process data by WinAC), the integration of SIMATIC IPC diagnostic data in WinCC or the maintenance station and pre-configured and installed bundles save costly tests and installation overhead.

SIMATIC Field PGs are preinstalled with selected SIMATIC software such as STEP 7 Professional, STEP 7 Basic, STEP 7 Micro/Win, STEP 5 and WinCC flexible Advanced for "ready to use" PLC programming and creation of visualization projects. The programming device is thus immediately available for productive use.
Links to further information:

SIMATIC IPC on the Internet:  
http://www.siemens.com/simatic-ipc

SIMATIC PG on the Internet:  
http://www.siemens.com/simatic-pg

Intel® Core™ processor family at Intel:  

Embedded processors from Intel:  

Intel White Paper on Intel® vPro™ Technology and Intel® Active Management Technology (Intel® AMT):  

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Subject to change.