The automation of factory floors is driven by the insatiable demand for higher productivity, lower total cost of ownership, and improved safety in industrial systems.

To meet this demand, industrial applications require faster computing performance, reconfigurability, higher data bandwidth, and higher system level integration.

Industrial applications are now pushing the limits of what traditional logic devices are able to deliver. This White Paper describes the trends and challenges seen by designers and how FPGA devices enable solutions to meet their stringent design goals.

Leading solutions for industrial automation

The author reviews three specific industrial automation solutions across a broad spectrum of industrial applications, ranging from video surveillance to manufacturing automation, indicating some common trends that drive the need for industrial-optimised semiconductor devices.

First, there is a shift from point-to-point data transfer to network-based communication. In video surveillance, this allows integrators to build larger, scalable, upgradeable, and more cost-effective systems for end customers. It also opens up video-stream accessibility to any device that can connect to the network, such as smartphones and tablets, for remote monitoring and control. Factory automation and control systems benefit from the expandability that networked communication and control offer, such as easily adding and upgrading equipment that is connected using standardised protocols.

The second major trend is towards miniaturisation of application processing systems.

Industrial surveillance cameras are beginning to incorporate sophisticated analytics and video processing in the camera itself, as opposed to sending video streams to a central server to be processed. Many factory equipment suppliers have learned that by incorporating sophisticated motor-control algorithms, they can use low-cost motors to do the job of large, expensive motors while reducing power consumption and improving reliability and safety. However, these control systems can take up much more space than is available at the motor, so the need for miniaturisation is critical.

The third major trend across industrial applications is an increased focus on lower power-consuming electronics. This is mostly a result of the need for miniaturisation, because when high-performance electronics are squeezed into a tight, sealed box, there is no way to quickly remove heat. As the heat inside the box increases, performance of the system is reduced, and excessive heat can eventually cause reliability concerns for the components in the system. In some cases, such as in surveillance cameras that use power over Ethernet (PoE), there is a strict power budget that must be adhered to. These major trends have led to a demand for high-performance, Ethernet-ready, low-power semiconductor devices to control the next generation of industrial machines.

Xilinx has developed a line-up of industrial-optimised logic devices based on cutting-edge 28 nm and 45 nm process technologies to specifically meet the unique needs of industrial systems. Xilinx FPGAs offer standard connectivity options from Ethernet powerlink to USB while also giving users the ability to achieve hardware-accelerated performance for custom algorithms. The devices range from low-cost and low-power to high-content and high-performance, facilitating designs in varying ranges of complexity. Table 1 summarises the selection of Xilinx industrial FPGAs and their corresponding focus applications.

The article reviews several advantages offered by FPGA devices:

**Programmable system integration**

Programmable SoCs (AP SoCs) deliver a completely new level of programmable systems integration - well beyond what Moore’s Law alone can provide. The modular cores are reusable across different applications. System designers can implement programmable system integration for applications where the processor needs to control different data streams, such as in motor control, video surveillance and Ethernet switching.

**Increased system performance**

FPGAs meet critical timing and performance requirements with parallel processing and real-time application performance. For example, in motor control, FPGAs enable real-time calculation for closing the control loop in less time.

**Bill of material (BOM) cost reduction**

FPGAs and AP SoCs cut costs by being more efficient. For example, in video surveillance, a single Zynq-7000 AP SoC can reduce bill of material cost by replacing ASIC/FPGA, DSP, and processor components. Features

<table>
<thead>
<tr>
<th>Device family</th>
<th>Process nodes</th>
<th>Sample industrial applications</th>
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<tbody>
<tr>
<td>Spartan - 6</td>
<td>45 nm</td>
<td>Industrial networking, motor control, data acquisition interface</td>
</tr>
<tr>
<td>Artix -7</td>
<td>28 nm</td>
<td>Image and video processing, machine vision, high-bandwidth data transmission</td>
</tr>
<tr>
<td>Zynq -7000</td>
<td>28 nm</td>
<td>Video surveillance, machine vision, motion control, industrial drive platform</td>
</tr>
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*Table 1: Characteristics of various Xilinx products.*
and functions supported by an FPGA can be updated long after deployment. In areas such as industrial networking and imaging, where the protocols and standards are shifting and changing, the programmability of FPGAs versus fixed-logic devices (e.g., ASICs and ASSPs) saves migration costs.

**Total power reduction**

Due to integration, low-power process, and power-optimised products, FPGAs consume less power.

**Accelerated design productivity**

Xilinx IP provides easy adaptation to changing interface requirements, rapid design iterations, and new feature additions. Vivado Design Suite for high-level synthesis (HLS) improves time to market upward of 2.5 times.

The image signal processor (ISP) for machine vision solutions can be implemented in FPGA logic, allowing for customisation of algorithms and faster time to market.

**Industrial networking advantages**

The factory ecosystem is an increasingly integrated workplace requiring interfaces across a wide range of applications, such as programmable logic controllers (PLCs), I/O modules, motors, sensors, etc. Industrial networking protocols provide seamless communication between modules, allowing components from different manufacturers to plug-and-play, provided they use the same protocols.

The communications in a factory can be classified into three levels: the Ethernet, process, and device levels. See Fig. 1.

- **Device level** provides communication between modules such as motor drives and its sensors, and needs to have the shortest response time.
- **Process level** is the mid-level communication between PLCs, using peer-to-peer formats, requiring a short response time but allowing a higher latency compared to device-level communication.
- **Finally, the highest level of communication** is the use of Ethernet, which provides the largest data bandwidth and distance to provide communication between various factory sites.

The paper includes various examples of industrial networking and industrial motor control and provides extensive data on available devices and applications including views on:

- **Machine vision**
  Machine vision is used in factory automation to detect/inspect manufacturing lines for quality control and for item tracking purposes. Another common use of machine vision is in vision-guided robotics. Machine vision comprises four components: image acquisition, processing, compression (if required), and transmission. All components of the machine vision can be realised using a single FPGA or a Zynq-7000 AP SoC.

**Video surveillance**

Current growth in the use of high-definition, internet protocol (IP)-based video cameras is exponential and is expected to hit 40-million cameras per year in 2014. There are currently many ASIC and ASSP video solutions on the market due to rapid development cycles and demand in the broadcast and consumer markets. FPGAs however allow for greater product differentiation because their flexibility allows for the implementation of special sensors as well as customer-specific IP and image processing functions. This is not cost-effective with a single ASIC and often not possible with an ASSP-based design. Such applications include multiple sensor dome cameras, High Definition cameras, night-vision cameras, etc. FPGAs provide the differentiation factor and the processing power to implement such complex solutions.

**Functional safety: IEC 61508**

Safety systems have always been a critical component of the manufacturing environment, responsible for monitoring the general health and operation of the manufacturing equipment and shutting down a process when something operates outside its specifications. Smart sensors and actuators with integrated safety features, such as diagnostics and testing, continue to be introduced to market. These smart sensors typically integrate an analogue sensor or multiple sensors with digital control logic to ensure that distributed control systems are continuously monitored for maximum safety.


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