Countries around the globe are turning to smart grids to improve efficiency and reliability, meet growing power demands, and incorporate renewable energy sources. However, the success of smart grids depends on the integrity and intelligence of the underlying components.

In this article, we show how the groundbreaking Intel® Atom™ processor E3800 product family delivers the reliability, security, performance, and efficiency that smart grids require. We also show how DFI is using these processors to power intelligent solutions for smart meters and substation communication systems. These solutions can help utilities leverage the smart grid to optimize energy production and delivery, meet growing demand with fewer power plants, reduce outages, improve customer service, and enhance environmental stewardship.

The Smart Grid Opportunity
In most countries, power generation plants produce electricity based on demand. The electricity produced then radiates out through a series of substations and progressively lower-voltage transmission lines to reach businesses, homes, and other customers.

In this age of the Internet of Things (IoT), transmission systems are undergoing a fundamental shift. The increasing processing power and connectivity now available for each grid component provides an opportunity to implement intelligence throughout a power generation and transmission system. These smart grids provide an important solution for today’s complex demands, which include everything from dealing with the high loads imposed by electric vehicles to incorporating intermittent generation sources such as wind and solar power. Equally significant, smart grid devices are resulting in a new era of communication between producer and consumer, enabling better energy management and improving the customer experience.

The efficiency gains can be substantial. A European Smart Metering Industry Group (ESMIG) review of 100 pilot smart meter projects found an average energy savings of 8.7 percent (source: “Empower Demand report – phase II,” ESMIG 2012). Such gains are driving market interest in smart meters and smart grids. The market research firm Lucintel predicts that the global smart grid market will reach approximately USD 57 million by 2016, with a compound annual growth rate (CAGR) of 13 percent from 2011 to 2016 (source: “Growth Opportunities in the Global Smart Grid Market 2011-2016: Trends, Forecast, and Regional Analysis,” Lucintel).

The Advantage of Intelligent Automation
To improve the efficiency, reliability, and sustainability of the production and distribution of electricity, intelligence and automation must be spread throughout the system. By automatically monitoring the flow of electricity, the grid can respond in real time to demand conditions and conservation opportunities, and can optimize everything from distribution to energy pricing. Nearly everything on a smart grid—from power plants to individual business and home appliances—can be designed for real-time monitoring and automated decision making.

Smart meters are a good example. They enable utilities to precisely determine power demand from each customer on the grid at any moment, as well as monitor supplementary production from customer devices such as solar panels. The information collected from smart meters can then be integrated and analyzed by other intelligent systems that automatically optimize the power grid. For example, smart meter data makes it easier for utilities to spot and act on potential power shortages by shifting supply to areas of higher demand. Smart meter data also makes it possible for utilities to provide real-time information to customers, helping them optimize their power use and reduce costs, further increasing the reliability and stability of the grid. For example, a smart dishwasher could wait to start its load until demand was low.

The Design Challenge
The power grid is the physical infrastructure: power plants, wires, substations, transformers, circuit breakers, capacitors, insulators, transmission towers, and other equipment. The smart grid adds a data layer onto this physical system to collect, network, and distribute
digital intelligence about each grid element in real time. Essential to a smart grid’s effectiveness is the ability to securely communicate this real-time intelligence from each element of the physical grid to all concerned parties, including power producers, power consumers, power marketers, grid operators, and asset owners. Embedded computers used in the smart grid handle tasks such as energy management, data communications, and information analysis.

With customers relying on electricity every minute of every day, smart grid components like smart meters and substations must meet high standards for operation. Criteria for these include the following:

- High reliability for 24/7 operation
- Security features to protect the grid and prevent potentially dangerous interactions
- Excellent connectivity, which requires both rich I/O as well as support for communications software
- High performance to gather and respond to data in real time, while also enabling passive cooling designs
- Small footprints for deployment in a variety of form factors
- Scalability to handle a full spectrum of smart grid needs

A Single-Chip Solution

The new Intel Atom processor E3800 family is a low-power System-on-Chip (SoC) that delivers outstanding compute performance, leading-edge connectivity, and excellent security and reliability in an extended range of thermal conditions for IoT designs. These qualities make it well suited for a range of smart grid applications like smart meters and substrate communication devices. Let’s look at how this processor family meets our specified smart grid device criteria.

High Reliability – This next generation Intel® Atom™ processor is the first to support error-correcting code (ECC) to deliver a high level of data integrity and reliability for smart grid devices. In addition, support for an industrial temperature range (-40 °C to 110 °C) enables reliability in extreme environments.

Security on the Grid – Security enhancements in this new processor family include hardware-assisted capabilities such as Intel® Advanced Encryption Standard New Instructions (Intel® AES-NI) and Secure Boot. Intel AES-NI helps eliminate the performance penalty for encryption and decryption features, making it easier to secure endpoints. Secure Boot defines an entirely new interface between operating system (OS) and firmware/BIOS, helping a system resist attacks and infection from malware by ensuring that only authorized software runs on a device. Detections are blocked from running before they can attack or infect the system.

The Intel Atom processor E3800 product family also includes Intel® Virtualization Technology (Intel® VT). This hardware-based technology increases virtualization performance by allowing the OS direct access to the hardware. Virtualization provides several important benefits by allowing multiple virtual machines to run on the same physical hardware. For example, developers can run McAfee® Deep Defender in its own virtual machine to provide below-the-OS protection for applications running in the main virtual machine. Virtualization also enables greater reliability, investment protection, ease of software migration, and flexible resource management.

Excellent Connectivity – A high degree of integration with industry-standard high-bandwidth interfaces such as PCI Express® Gen 2.0, Hi-Speed USB 2.0, and USB 3.0 ensure expansion and storage capabilities wherever these processors are used in the grid. What’s more, use of an Intel® processor ensures compatibility with a broad range of popular OSs, BIOSs, and software, simplifying software migration, connectivity, and data exchange with other devices – an important element in the design of smart grids.

High Performance in a Low-Power Design – Based on the Silvermont microarchitecture, the Intel Atom processor E3800 product family uses Intel’s industry-leading 22 nm process technology with 3-D Tri-Gate transistors. This new microarchitecture incorporates numerous innovations, such as a new out-of-order execution engine that delivers up to 3x faster performance than the earlier Intel® Atom™ processor N2000/D2000 family. In smart grid components, these innovations deliver superior energy analysis performance and outstanding power management capabilities. The new SoC is also up to 3x more energy efficient than its predecessors, and standby power is reduced to milliwatts to save power in applications like smart meters that spend significant time in sleep states.

Small Footprint – By integrating all necessary components in a single SoC, the Intel Atom processor E3800 family enables high levels of functionality in small form factor solutions. This SoC design, with its integrated memory controller and graphics, also helps reduce bill of materials (BOM).
Superior Scalability – With thermal design power (TDP) ranging from 5 W to 10 W and processors available with one to four cores (Figure 1, Page 19), this product family offers excellent scalability within the product line, as well as with other Intel processors, to provide scalable solutions for everything from entry-level to high-performance systems.

Example Solutions
Developers can quickly deliver products based on the Intel Atom processor E3800 family by using Qseven* and Mini-ITX solutions from DFI. These platforms take full advantage of the performance, energy efficiency, reliability, security, connectivity, and compatibility of the new processors to deliver marketable benefits for smart meters and substations. As shown in Figure 2, these two solutions can provide reliable communications between the smart meter and the intelligent substation. The substation can then report electric power consumption and generation information back to the electric power control center station, providing important business intelligence information for current operations and future planning.

Smart Meters
The DFI BT700 is a Qseven module based on the Intel® Atom™ processor E3822 (Figure 3). This module offers a compact 70 mm x 70 mm footprint that can readily fit within a smart meter form factor, as well as an MXM system connector with standardized high-speed I/O. Data collected from the meter can be transmitted to the substation communication system via LAN or UART. The LAN controller used on BT700 is the Intel® Ethernet Controller I210-AT. Integrated with up to a 1 GB transceiver, it can significantly increase the transmission speed for network-intensive applications.

The Intel Atom processor E3822 consumes only 7 W, providing an efficient answer to the requirements of smart meters. In addition, the DFI BT700 supports an extended temperature range of -20 °C to +70 °C for extreme operating environments. For system memory, the BT700 is equipped with up to 4 GB of DDR3 at 1333 MHz (or dual-channel DDR3 at 1066 MHz) for fast communication between components.

Substation Communication Systems
The DFI BT161 Mini-ITX board uses the the Intel® Atom™ processor E3840 to provide a stable, revision-controlled platform for the communication system in the substation (Figure 4). These communications enable equipment monitoring, control, outage detection, and delivery of messages such as energy-efficiency incentives.
The 10 W processor provides excellent compute performance in an energy-efficient SoC, making this board suitable for a wide range of utility designs. The BT161 motherboard is also packed with four USB ports, four COM ports, two SATA 2.0 ports with data transfer rates up to 3 Gbps, two Intel Ethernet Controller I210-AT controllers, a 12 V DC input jack, and an 8-bit digital I/O connector for device control. In addition to the I/O built into the Mini-ITX board, the BT161 is designed with DFI’s proprietary ECX daughterboard interface for installing additional I/O, such as USB, serial port, PS/2, and PCIe x1 to meet different needs. The BT161 also comes with an LPC connector that supports additional COM and parallel ports via DFI’s proprietary LPC module.

A Head Start on the Smart Grid
By making energy distribution more stable and intelligent, smart grids provide valuable ways to improve energy usage efficiency, manage demand during peak hours, and reduce the overall costs of delivering power to end users. As energy consumption around the world grows, such managing and monitoring of energy consumption will become increasingly important. The need for better control of supply and demand through intelligent systems powered by advanced processors such as the Intel Atom processor E3800 product family will enable the more complex interactions that smart metering technologies require. Best of all, DFI's BT170 and BT161 give developers a valuable head start in developing smart grid products, providing the required performance, small footprint, energy efficiency, security, and reliability to be a leader in this field.

For more on the BT700, see intel.com/SD-DFI-BT700; for more on the BT161, see intel.com/SD-DFI-BT161

To learn more about connected, secure energy solutions, see intel.com/embedded-energy

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