Smart power opens door to more efficient electrical use

How intelligent will our homes and buildings become?

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Suppose you are 1,000 miles from home, yet have the ability to monitor and control every watt of power in your home or office building from the palm of your hand. What could you do with that capability?

Sometimes you might want to change the thermostat remotely, or turn on the lights and start the coffee maker. But consider, too, that you could make real-time decisions on power usage based on instantaneous knowledge of power grid capacity and costs. Imagine having the knowledge and control to pad your own wallet or the company bottom line through optimal energy use and savings. At your fingertips you'd have a tool for generating money, every minute of every day, and all from a smartphone.

Such scenarios were visionary only a few years ago. Today they're increasingly realistic, as homeowners and landlords everywhere are taking control of energy consumption to an extent never possible before. Power is becoming smarter at every stage, from its generation centrally or locally to its end use in smarter homes and buildings by the electrical devices that we use at home, at work and on the go.

These advances in power monitoring, connectivity and control—known collectively as smart power—are enabled by advanced semiconductor technology. Texas Instruments (TI) is among the technology innovators committed to smart power development. System developers can rely on TI's in-depth expertise and long-term product development in power, network communications and control circuitry to deliver greater intelligence into the generation, transmission and consumption of energy.

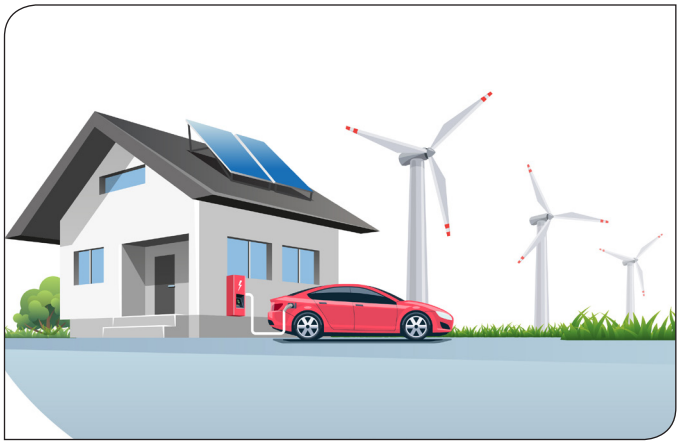
Smarter power generation

Power generation and transmission are undergoing a slow but steady evolution to smarter, finer-grained supply when and where energy is needed. On an industrial scale, service providers are investing in alternative sources of energy such as solar and wind farms, as well as working to utilize central power stations more efficiently. Power equipment is also becoming more intelligent and increasingly is data-networked in order to minimize transmission, connection and conversion losses.

Moreover, supplying energy is no longer the task of service providers alone. Residential and commercial buildings are becoming energy generators as well, with small-scale installations in wind and, especially, solar technology. For small producers, smart power manages the production, storage and use of electricity, as well as enabling them to feed electricity into the grid at times of over generation.

Enabling smarter homes and buildings

Intelligent power use is increasingly benefiting homes and office buildings. Sensors direct lights to dim or turn on and off, and to increase or decrease ventilation, depending on the presence of people in the space. Energy networks may include features such as software that analyzes power usage by individual areas, applications and equipments. Such programs help to determine whether equipment needs to be replaced, either because inefficient operation makes it costly, or because it is critical and must not fail. An energy network is also essential if the building generates electricity via solar or wind energy harvesting.



Smart homes are becoming energy generators to manage production, storage and energy usage.

Business landlords who invest in smart power systems find that their electrical spending goes down considerably, and they often save enough to pay back the installation investment through increases in productivity that result from keeping the workspace comfortable. In addition, since the need for power is ubiquitous, it makes sense to extend the concept of smart power to enable smart buildings. Networks with connected applications such as structural monitors, security systems, smoke detectors and motion and occupancy sensing serve to create a management-savvy nervous system for the entire building.

Technology for smarter power

A number of different technologies are used to enhance the energy management of buildings, not to mention other forms of building monitoring that may be closely coupled. Sensors detect ambient temperature, body heat, light levels, carbon dioxide levels and a variety of other conditions, such as the presence of vibrations, smoke and hazardous chemicals. Area control units monitor the data from different sensors and initiate actions such as dimming lights, redirecting ventilation, changing thermostat settings and other factors. Master control units run complex software that analyzes the activity of the entire network in order to provide operational evaluation, equipment alerts, cost breakdowns and other outputs.

These systems all depend on communications via wired or wireless media, and at various points signal conversion, microcontrollers (MCUs) and other logic, memories and different forms of interface circuitry are used. Power management circuitry is used in all units, and it is especially important for regulating, converting and controlling the generation of electricity by alternative energy sources and its storage in batteries.

Understanding semiconductor requirements

Because smart power systems are varied, so are the requirements made on semiconductor technology. Sensors are usually small, independently operating systems that can exist in great numbers, sometimes in locations that are hard to access. In addition to the sensing element itself, a sensor often requires signal conversion circuitry to

change analog signal inputs to digital data, a small amount of memory and logic, a communications interface and a transmitter for reporting the data via a wired or wireless link. The key requirements for these units are normally small size, affordable cost, and—since they may have to operate from a battery for extended periods without maintenance—ultra-low power consumption.

Area control units, which may be housed with switches, thermostats and other circuitry, require the above elements plus additional control logic and memory and the ability to receive and transmit data for control and reprogramming. In a commercial building or a house with an advanced smart power network, several area control units report to a master control unit. This unit in turn may be networked with the Internet, the regional electric grid and other building-level and external networks.

Overcoming network communication challenges

Communications and connectivity standards among these systems are various. The central, wired systems that deal with large amounts of data for analysis and planning use the Internet Protocol (IP) for most forms of data exchange, and in some cases the smaller units may send and receive IP packet data over wired or wireless connectivity links. However, wireless sensors may use a protocol such as ZigBee® that is designed to minimize power consumption in local-area transmissions. Wireless connectivity systems offer a significant advantage in that they require little or no change in wired infrastructure, saving installation costs and permitting more devices to be deployed for finer-grained data gathering and control of smaller spatial zones. For this reason, even wire-powered devices may rely on some form of wireless connectivity or power line communication (PLC) in order to avoid installing separate network wiring.

Smart power enables smart buildings with energy networks that power a range of applications and equipment.

PLC may also be used outside the building to extend network sensing and control to lights, access points, alarms and other functions.

All networks that communicate to external sources require some form of security to prevent accidental or malicious entry. Smart building power networks are no different, and both hardware and software need to include security measures.

In city-wide networks, similar technology issues apply for devices such as street lights and traffic infrastructure, as well as for transformers and other units in the electric power grid. Smart buildings fit into a pattern of smart power innovations that are occurring at all levels of private and public usage.

Searching for smart power solutions

Smart power technology is continually improving and being applied in new and innovative ways. In addition to meeting demands for compact size, extremely low power consumption and varying levels of performance, IC solutions must be capable of supporting flexible configurations, especially in communications where a variety of protocols are used. Analog signal chain functions such as data converters are also key elements, as are management, regulation and control functions for system power.

System developers need to consider the benefits of finding as many of these components as possible from a single IC supplier to simplify design and procurement processes and to assure compatibility among the various, complex functions each component provides. Other capabilities such as integration can help support long-term roadmaps for later product generations, and the availability of a range of packaging options offers flexibility for various board requirements.

Another critical technical capability in the delivery of smart power is isolation, which protects circuitry from high-voltage and high-current surges. Isolation also maintains operational integrity by preventing high-frequency signals from entering into low-frequency circuitry, where they may corrupt data. By nature, smart power systems combine different types of circuitry and require reliable isolation techniques in order to function properly. For more on isolation, see our related white paper here.

TI solutions for smart power

Developers looking for IC solutions for their smart power systems will find that the breadth and depth of TI's product offerings address the requirements described above. As the industry's leading provider of power-related ICs, TI has not only a full range of power management devices but also the expertise required to create innovative solutions for smart power networks. This expertise extends to features, such as power factor correction (PFC), that help guarantee the quality of power input and will be increasingly important in the complex electric grids of the future. TI also is recognized for its ultra-low-power technology in MCUs and wireless connectivity products, advanced analog signal chain solutions and a wide-ranging portfolio of networking, connectivity interface and communications devices.

In addition, TI's advanced analog manufacturing processes, including gallium-nitride (GaN) for high-speed switching power supplies, have led to important advances in isolation techniques that prove beneficial throughout its product lines. TI's technology strengths and its wide range of product selections position the company well to supply the flexible solutions for delivering smart power at all levels.

Smart power for a smarter future

The challenge we face in the years ahead is how to squeeze as much useful performance as we can from the energy we generate—whether the generation is from rooftop solar panels and backyard windmills or giant power plants. Smart homes and office buildings can add considerably to efficient, responsible use of energy, saving money and minimizing environmental impact while also giving consumers and business managers greater control over their building infrastructure.

Smart power depends on intelligent technology, including sensors, wireless connectivity and communications, control units and software—not to mention the innovation that gathers all these pieces into a network with advanced applications. TI brings a long history of developing expertise and supplying products in these areas to the smart power problems we face today. With the aim of cultivating a greener world, TI creates technologies that enhance our lives by making homes, offices, factories and vehicles smarter for the future.

For more information, check out TI's grid infrastructure and building automation reference designs.

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