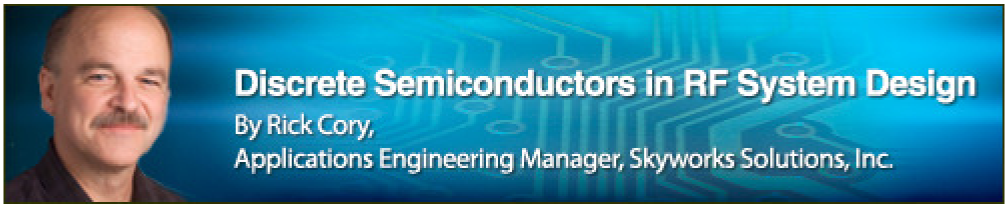

Smart Energy: The Cure For Chaos?

By Rick Cory, Skyworks Solutions, Inc.

Consumers' demand for and use of electrical energy is very nearly chaotic anarchy. If we had an infinite supply of accessible energy, this would present no significant problems, but we all know that the present sources of electrical energy, especially those based upon petroleum and other fossil fuels, are finite.

The world's population is growing (it has nearly tripled in my lifetime!) and the standards of living in the two most populous countries in the world — China and India, who account for roughly 36% of the world population — are rapidly advancing. It is increasingly important to effectively and efficiently apply the energy resources that are available to the consequent increasing demand. We all want to use electricity to light our homes, schools, and businesses; to condition the air in these premises to keep us comfortable; to keep our food safer through refrigeration; and more.

Consider how much energy we use for entertainment. How many of us have as many televisions in our homes as people who live there, a cell phone (or two) that needs regular recharging, personal computers, video games, etc.? How many of us always leave several "wall wart" charger units plugged in, whether they are being used to charge a device or not? The presence of electrical apparati in our lives is growing at a remarkable rate.

The world's climate appears to be changing. Global warming has been attributed to large concentrations of greenhouse gases, especially carbon dioxide (CO_2), which are byproducts of the combustion of fossil fuels. Until automobile manufacturers develop electric vehicles that can be mainly charged from solar power, the trend towards electric vehicles to replace vehicles powered by internal combustion engines will significantly add to the larger demand for electricity from the existing power grid.

The current business model for delivery of electrical energy is a pull system. Energy consumers independently pull power from the grid to charge their portable entertainment devices, and to operate their heating systems, their cooling systems, their lights, etc. Energy providers do their best to anticipate demand for power, but as good as they are, they can only formulate

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educated guesses about how large consumer demand will be at any time. In the event that the energy providers overestimate demand, they will have excess capacity available, which may waste increasingly precious fossil fuels. Worse, if they underestimate energy demand, they may be forced to institute brownouts, in which they reduce the voltage supplied to portions of the power grid, or in more extreme conditions blackouts, in which they completely disconnect sections of the grid, in order to reduce the load placed upon their generation systems. These scenarios are clearly undesirable to all parties: energy consumers are inconvenienced (or worse), while the energy providers miss opportunities for revenue and may incur costs for repair of overburdened portions of their infrastructure.

C^3

Communication, command, and control (C^3) is a concept well known in the military world and may have a significant part to play in mitigating the mismatch between orderly supply of and unruly demand for energy. In order for a military organization to be effective, all the components that comprise the military organization must be able to communicate with each other in an efficient, timely manner in situations that are even more chaotic than that of the energy demand-supply relationship. The leadership of the military organization must be in charge of all of its subordinates in order to coordinate their efforts, and the subordinates must implement the policies, strategies, and tactics prescribed by the leadership. Failure in any part of this triad can result in very dire consequences.

The principles of C^3 can be applied to the generation, delivery, and consumption of electrical power. The first step in implementing a version of C^3 is communications, from the point of consumption back to the energy service provider. Traditionally, the only communications that occurred were the result of the service provider's employees, who would physically visit the premises of every end customer to read a meter that would measure the use of energy at that location. This approach had many problems: It was very expensive to send people to every customer every month, and it was sometimes even hazardous for the employees (we have all heard stories about dogs who "took exception" to the presence of the meter reader encroaching in their territory). And maybe the biggest weakness of all, this method of communications was historical in nature — by the time the energy company determined how much energy was used in the preceding billing period, it was too late for the consumer to do anything about excess or unintended energy consumption except to grimace and pay the bill.

Enter The Smart Grid

The smart grid adds a significant dimension to the energy delivery system: two-way, real-time communications between the energy consumer and provider. This communication will primarily take place via unlicensed radio band communications. Today there are already radio solutions, most of which employ the ZigBee® protocol at 2.4 GHz, which allow energy consumers to monitor their energy use as recorded by their power meter on a real-time basis by means of a display module that is mounted at a convenient location within their premises. This protocol has an adequate data rate capacity for such communications, but most ZigBee chipsets do not have sufficiently large transmitter output power, or sufficiently low receiver noise figure, to enable communications over paths lengths longer than a few tens of meters. An attractive market is developing for RF components manufacturers to provide RF front end modules, comprising a power amplifier, possibly a low noise amplifier, a transmit/receive switch, balun transformers, etc., which can be married to ZigBee transceiver chips to meet the demands of intermediate-range smart grid implementations.

Command And Control

Future features of the smart grid will impose some order on the chaotic pull system described above. Appliances that use electrical energy will also have the ability to communicate with the service provider via radio communications, which includes the ZigBee short- to intermediate-range communications between the energy metering device, as well as longer-range backhaul radio communications (cellular telephone networks, WiMAX, dedicated point-to-point radio links, et al) between customers' premises and energy providers' facilities. This effectively will allow the service providers, in the event that their capacity to provide energy is oversubscribed, to replace the brute force remedies of brownout or blackout with surgically precise remedies of shutting down or "throttling back" nonessential points of energy consumption, such as entertainment devices, etc., in order to match demand to supply.

It is anticipated that electric vehicles will be recharged mainly during off-peak periods, but this is not necessarily so. Since the effective range of current electric-only vehicles is still somewhat limited, it is likely that recharging stations will become widely available at destinations as well as at residences. The vehicles that are connected to these charging stations do not only present loads to the smart grid, they also present potential reservoirs of reserve power to the grid, assuming that charging stations will have the capability to convert the DC energy stored in the vehicles' batteries to AC energy which is compatible with the grid. If spikes in demand occur, energy may be briefly drawn from connected vehicles and then replaced when the spike has subsided. Radio communications will also play an important role in such situations, allowing the smart grid to pick and choose which vehicles could source energy and which vehicles should be left alone to continue charging, or possibly to simply have their charging interrupted until the spike passes.

The *raison d'être* for engineers is to impose order on chaos, to replace entropy with organization. RF communications is a key enabler for the implementation of the smart grid to accomplish those goals.

For more information, please visit **www.skyworksinc.com**.

About the Author

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