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APPLICATION NOTE 5330

Achieving Significant Power from Renewables

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Abstract: Renewable energy sources hold tremendous potential for transformation of how societies generate energy, and integration of these sources is now being driven by government and utility organizations. Following generation, measurement and efficient conversion to grid-compliant AC are critical for smoothly integrating renewable energy sources. Communication of that available energy is also required. This article reviews technologies available for integration of large-scale and small-scale energy sources.

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Introduction

Imagine a world in which all electricity comes from renewable sources. Now, consider that the 2011 European Commission Energy Roadmap 2050[1] proposed a future scenario in which 97% of consumed electricity would actually be generated from renewable sources. Yes, the goal is 97%. What would such a world look like? Close your eyes and see the images of clean air, blue skies, and green pastures. Wonderful, yes, but not before considerable work is done. For us engineers, the vision and dream of a "green" new world quickly gets replaced by a difficult, ultra-large-scale engineering project. Can we harvest, aggregate, and deliver enough renewable energy to reach the point where renewables essentially deliver all necessary electrical energy? That is most definitely the challenge.

Harnessing the Main Sources of Renewable Energy

Renewable sources are certainly very attractive options for generating energy. The sun and wind are free, prolific, and permanent. After an initial setup investment, they can be made to produce clean, inexpensive, reliable energy for years. Concurrently, new chemistries such as copper indium gallium selenide (CIGS) and nanoparticles have transformed photovoltaics, allowing for lower production costs and flexible form factors. In addition, high-volume production continues to drive down the cost of conventional silicon and polysilicon panels.

But there is yet another step in the integration of renewable energy sources. After creating electricity

from photovoltaic cells, that energy needs to be converted to AC power for use on the grid. To be cost effective, this inversion step must be efficient. In complete photovoltaic systems today, the "balance of the system" (i.e., all components except the panels) now accounts for 44.8% of the system cost. That percentage will increase in 2012.[2] Consequently, there is no argument that these electronics must work efficiently and reliably.

If a utility wants to generate a large majority of energy from renewable sources, then massive installations for solar, wind, and hydroelectric generation must occur. In addition, the distribution grid must be capable of transporting, and likely also storing, these large distributed and intermittent energy sources. Furthermore, conservation and efficiency must also play a significant role. Technologies like LED lighting would require mass adoption.

Scale Down to Energy Harvesting as Another Option

There is another intriguing alternative energy story worthy of discussion: energy harvesting. Here the task is to think beyond different sources of energy and consider the *scale* of these sources. A large wind farm or an acre-sized solar farm in the desert provides a tremendous amount of electricity. But what about the breeze that blows leaves across the ground or the ray of sunlight shining through the window? If you consider the scale of these sources, you open up a new range of applications and ideas. You can, in fact, greatly increase the reach of renewable energy.

It takes some creativity. Imagine a cell phone that charges itself from radio waves in the air; road sensors, powered solely by the weight of wheels running over them, that report traffic conditions; solar-coated windows that allow specific amounts of sunlight to illuminate and heat a building and then use the remaining sunlight to produce electricity. These small-scale applications, called energy harvesting, are not only possible, but they are closer than you think. These renewable sources require intelligent handling of energy to make the smallest amount of wind, vibration, or sunlight useful.

Achieving the Significant Power

Small-Scale Energy Generation

Renewable sources and scale of resources—this is really what we are talking about. Up to this point I have spoken about what some consider "the obvious." Now we can talk about what is already happening. Maxim Integrated is offering many products that span the breadth of alternative energy solutions, from small-scale energy harvesting to large-scale solar implementations. For ultra-small energy generation, the MAX17710 (**Figure 1**) provides intelligent conversion of any source that generates more than 1µW of energy. The IC is considered to be "energy-source agnostic" because it harvests energy from heat, light, vibration, and magnetic sources. The result is a usable voltage that can charge a microcell battery while simultaneously running a sensor.

In a world relying almost entirely on renewable energy, these microsources of power will be a necessary part of the energy portfolio. This is also why energy harvesting tools like the MAX17710 will be so necessary in the future.
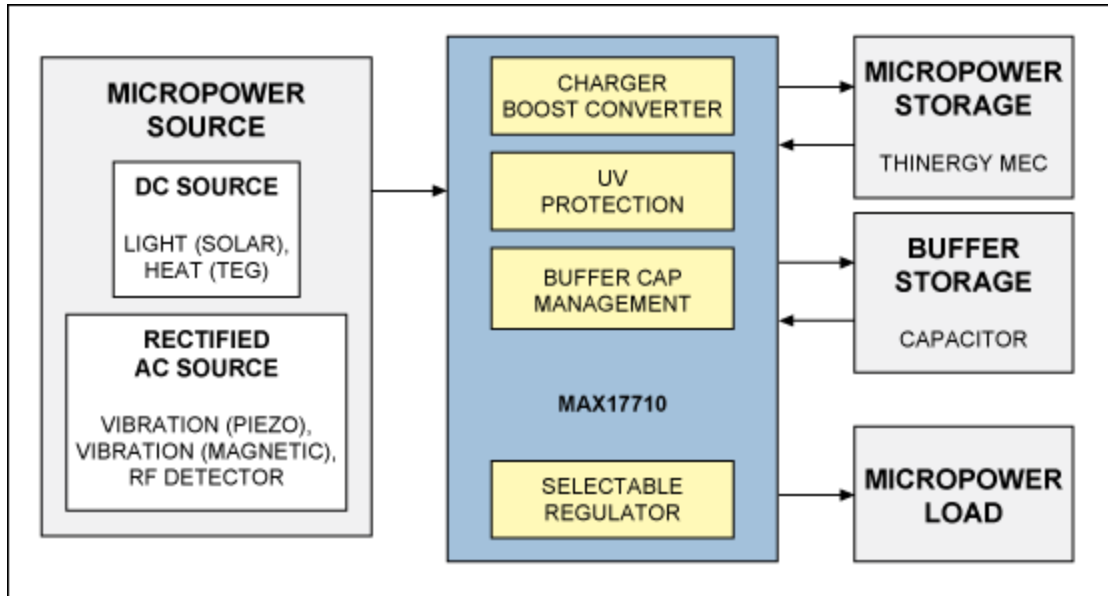
Figure 1. A block diagram of the MAX17710 energy-harvesting charger along with potential energy sources and storage elements or loads.

Medium- and Large-Scale Energy Generation

In medium- and large-scale solar installations, measuring the produced energy provides insight into the status of system operation. The 78M6613 energy-measurement chip accurately measures DC or AC energy to 0.5% across a dynamic range of 2000:1. Actual data is shown in **Figure 2**. This accuracy and range let power producers monitor and gauge the system performance of their rooftop solar panels that are producing energy in the morning and evening, even in the weakest sunshine.
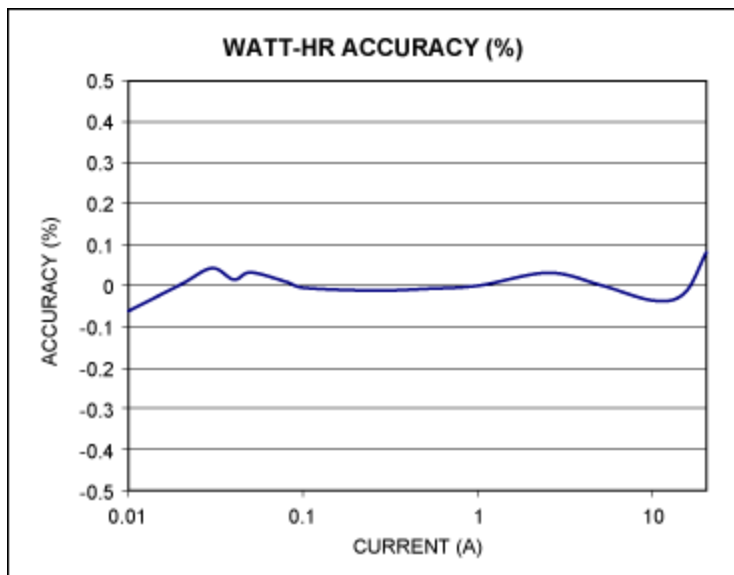

Figure 2. Actual data for energy measurement with a calibrated 78M6613.

The 78M6613 also uses four-quadrant measurement to provide an accurate power factor, which determines both the efficiency of transmission and the readiness of the power to go out on the grid. With

8 channels, the 78M6618 energy measurement IC provides similar functionality for applications requiring multiple points of measurement. The 78M6631 thus works in large-scale 3-phase commercial systems. As renewable power becomes a greater percentage of power on grids, utilities will rely on the accuracy and speed of these energy measurements to maintain power delivery while smoothly integrating variable sources.

Measuring, Metering, and Communicating the Power

Renewable energy sources are generally intermittent—the wind is not always blowing nor is the sun always shining brightly. Consequently, to ensure an adequate energy supply when users want it, high quantities of renewable generation will be required. Energy storage on the grid will also be required to buffer the variability of source and demand. Moreover, many of these systems will operate entirely "off grid."

When you speak of generating power from renewables, you do not normally think about battery management. But when you consider the issues of energy storage, battery-management techniques become critically important. Battery chemistries evolve based on application and technology, but safety and continuous battery operation remain the primary requirements. To meet these performance requirements, Maxim offers a variety of 12-cell battery-management products. The MAX11068 manages the energy of up to 12 battery cells, providing integrated cell balancing and over-/undervoltage (OV/UV) detection. For high-voltage applications, the part can also be connected in a daisy-chain configuration of up to 31 modules to manage up to 372 cells. Because it is designed to operate in the -40°C to +105°C temperature range, the harshest winter and summer conditions will not interrupt battery operation.

Power from solar panels must also be converted from DC to AC. This requires a series of frequency switching. Robust and reliable MOSFET drivers, such as the MAX15024 and MAX5048, provide efficient signals to drive the MOSFETs that invert the power.

Once the inverter converts the power to grid-compliant AC, that inverter must also communicate over the grid. This communication tells the utility that it can route the energy for the most efficient performance. Maxim's G3-PLC™ chipset, the MAX2991 and MAX2992, communicates across powerlines, even in high-noise situations. **Figure 3** schematically shows that G3-PLC also communicates across transformers from low-voltage to medium-voltage powerlines, thereby reducing the number of access points necessary in a powerline network. This communication method is already used in multiple smart meter trials, including the Electricité Réseau Distribution France (ERDF) trial in France.[3] In addition, G3-PLC works effectively for communication within the photovoltaic system. Other forms of communication within a photovoltaic system and from a solar system-to-grid include RS-485, CAN bus, and RF. Maxim provides solutions for all these interfaces.
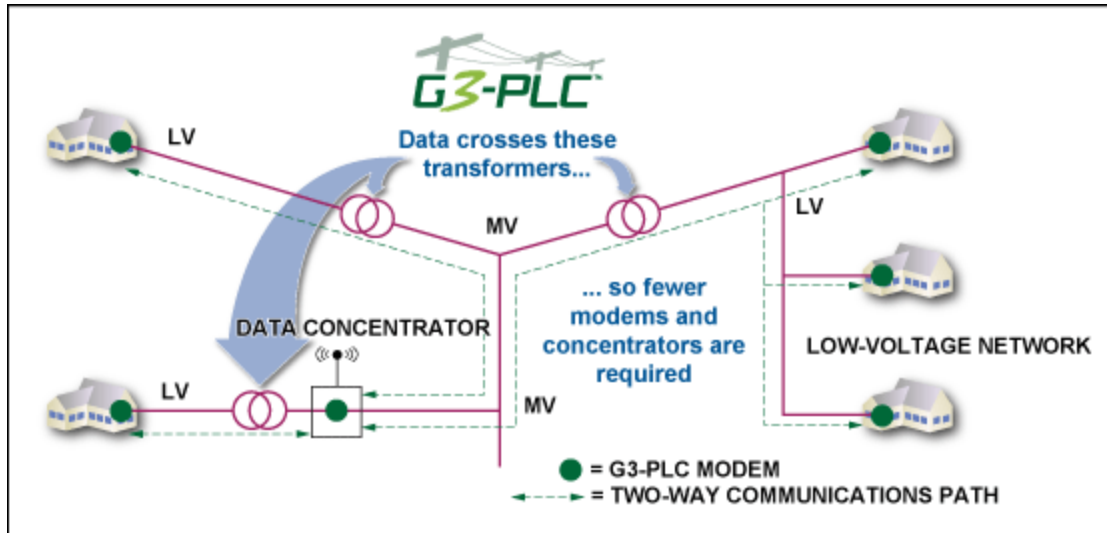
Figure 3. Schematic of G3-PLC communications. Crossing transformers from low-voltage to medium-voltage powerlines reduces the number of access points required in a utility's network.

The Situation Today

Data indicates that we can achieve significant power with renewables. No one is debating the environmental benefits that will come with renewable integration and conservation. One thing is clear, however. These benefits cannot be achieved without carefully managed renewable resources and a well-engineered grid.

The European Commission Energy Roadmap 2050 scenario of 97% renewable energy is clearly ambitious. Achieving something close to that would be a tremendous engineering achievement and likely require the next 50 years. Achieving significant power from renewables must merge engineering creativity, ambitious utility companies, and circuits optimized for the conversion, measurement, and communication of energy sources. When that happens, we will all win.

References

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G3-PLC is a trademark of Maxim Integrated Products, Inc.

Related Parts

78M6613	Single-Phase AC Power-Measurement IC	Free Samples
78M6618	Octal Power and Energy Measurement IC	Free Samples
78M6631	3-Phase Power Measurement and Monitoring SoC	Free Samples
MAX11068	12-Channel, High-Voltage Sensor, Smart Data-Acquisition Interface	
MAX15024	Single/Dual, 16ns, High Sink/Source Current Gate Drivers	Free Samples
MAX17710	Energy-Harvesting Charger and Protector	Free Samples
MAX2991	Power-Line Communications (PLC) Integrated Analog Front-End Transceiver	Free Samples
MAX2992	G3-PLC MAC/PHY Powerline Transceiver	Free Samples
MAX5048	7.6A, 12ns, SOT23/TDFN MOSFET Driver	Free Samples

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