Electrical engineering professor working to make solar power more affordable

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Balog describes the equipment to Samantha Castillo and Souhib Harb.

With the growing need for alternative energy sources, one professor in the Department of Electrical and Computer Engineering at Texas A&M University has developed a way for the average household to install solar power.

Dr. Robert Balog, an assistant professor, recently received a patent that makes it both more feasible and cost-effective for homeowners to install solar panels. The technology minimizes the double-frequency ripple power exchanged between the single-phase ac home electrical system and the dc photovoltaic (solar panel) energy source. Double frequency power is inherent in the physics any single-phase alternating current systems and arises from the sinusoidally varying voltage and current,

which give both average power flow and power flow at twice the grid frequency.

“Photovoltaic cells are most efficient when they generate only average power, so preventing the double-frequency power from reaching the cells is absolutely critical to maximizing the energy conversion efficiency,” Balog said.

The new method does this by combining power electronic circuit elements, a control algorithm, and exploiting basic conservation laws.

“This new technology is a mathematically derived minimum energy condition in which much less capacitance is needed, so more reliable film capacitors (more expensive per microfarad) can be used without increasing the total system cost,” Balog said.

The method senses the sinusoidal grid voltage and generates an internal AC waveform having the same frequency as the grid only shifted in phase by pi/4 radians The power flow due to these two voltages is combined by the circuitry and the result is that the double-frequency ripple power reaching the PV cells is minimized.

“Traditionally, the weak link in the photovoltaic energy system was the power converter, called the inverter,” he said “The way it handled the double-frequency power can best be described as ‘brute force.’”

The physics tells us that 0.53J of energy is needed to manage the double frequency power in a 200W inverter. Inside of a conventionally designed inverters are numerous large electrolytic capacitors that absorbed the power ripple. The 200W inverter may require 11,000uF, which stores 13J of stored energy — 25 times what is needed to filter the power ripple.

Balog said that the problem is that the only cost effective capacitor technology for this high of capacitance is the aluminum electrolytic type, which is well known by power electronics experts to have limited reliability, particularly in hotter environments like Texas — ironic because the same environment ideal for solar electricity generation is the most detrimental for a key component of the system.

This patent reduces the amount of capacitance by a factor or over 1,000. This allows the use of film capacitors instead of aluminum electrolytic ones. Although they cost more per microfarad, much less is needed and they have vastly superior reliability and operational lifetime.

“It allows us to manage the power ripple in a single phase power system in a way that’s never been done before,” Balog said. “While the technology can be applied to any scale PV system, it is particularly suited for residential solar.

“Unlike commercial power producers, most homeowners aren’t used to thinking of product life-cycle and replacement costs. Improving the reliability means a better return on investment but more importantly, no unplanned repair expenses down the road.”
While many people are interested in solar energy, Balog said there’s a large barrier because the technology is very expensive. Previously the options were very limited and an interested homeowner would have to install a large system of perhaps 15 panels at a cost of approximately $25,000 (less any rebates and government incentives). His technology allows homeowners to purchase and install individual single solar panels.

“They can install one panel at a time instead of all or nothing,” he said. “Considering that the cost of one or two panels is about the same as the average US personal tax refund, someone can say, ‘I got my tax refund so now I can go solar,’ and do the same next year. The more panels they have the more power is generated and over the course of years they build

it up and use less and less fossil fuel energy.

“Before this technology existed the inverter which processes the power from the solar panels into the power grid had a 10-year warranty because the technology that was needed for this double frequency ripple was fundamentally limited.”

Balog adds that this new technology allows for a design that can have a 25-year warranty so for the first time all the pieces of the system have the same 25-year warranty.

“For those who are not technologically sophisticated they might see a solar system as a confusing conglomeration of components that don’t make sense, one is warrantied for 25 years and another for 10 years,” he said. “This technology is designed to bring the system together so you have components more combatable with each other which will hopefully enable companies to have more comprehensive warranties and to increase the peace of mind of the homeowners. A true turn-key energy system.”

Balog’s research stems from work he did before joining Texas A&M at an Illinois-based technology startup company, now headquartered in Austin. His current research seeks to continue to address the fundamental challenges and develop the technology needed to make solar more accessible to average people. And he has several students assisting him with his research.

One of the students Balog said is looking at reliability aspects while another student is looking at the PV installation aspects. Poor reliability means added cost later to repair or replace failed components.

“We’re investigating technologies to help those without the ‘perfect solar roof’ to still be able to harness the power of the sun in a way that makes

economic sense," he said.

Balog added that another student is studying optimization (cost, performance, size and weight) and another student is looking at advanced circuits that could embody the technology of this recent patent and implement it ways that better utilize the potential and further improve its reliability. And all his students seem excited about working with him on something that could have such a huge impact.

"Coming from small country that does not have oil to produce power and rely on importing it from outside, necessitates the search for alternative energy resources," said Souhib Mohammad Ali Harb, a Ph.D. student working with Balog. "The solar energy offers a clean and sustainable alternative, hence finding efficient techniques to harvest that energy is highly needed."

Studies have shown that solar power is one of the fastest growing forms of electric generation in the United States and Balog hopes that with this new patent and other technologies he is developing, it will grow even more.

When asked about the outlook for photovoltaic systems on the Texas A&M, College Station campus, Balog said, "We are currently working on a couple of demonstration projects that will have a very visible presence on campus."

Provided by Texas A&M University