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Inverters and beyond

Inverters, converters, combiners and recombiner boxes – Joyce Laird delves into the latest designs at the heart of today’s modern renewable energy systems.

INVERTERS ARE a well recognised part of all solar photovoltaic (PV) systems today. The DC/DC converter is a relatively new product. Combiners, recombiners, inverters and converters act together as the pathway to create power suited for the grid.

Headquartered in France, **Schneider Electric** manufactures and markets all the balance of system components, including inverters, AC and DC disconnects, string combiners, recombiner boxes, local and remote switchgear, and transformers. “We do design work for grid sub-stations and large utility installations and have two distinct SCADA offers that we deploy in the solar space,” says Rudy Wodrich, the company’s Vice President of Solar.

Three new technologies have recently been introduced by the firm. The Conext SW inverter is a backup product for the low-end price range, 3.5-4 kilowatt size PV projects that are completely off grid. “This is a pure sine wave inverter,” Wodrich says. “It is a grid-forming inverter, so it works in conjunction with batteries or a grid-tied solar system to create a mini-grid without the need for an external utility connection.”

Online: renewableenergyfocus.com

Inverters: quality is the future
<http://tinyurl.com/cno8x3p>

Chinese solar PV inverter market grew 400% in 2011
<http://tinyurl.com/c67lbv7>

Partner in solar power: Part Two
<http://tinyurl.com/d3s9xes>

Partner in solar power: Part One
<http://tinyurl.com/cwswygs>



The second device is called the Conext Combox Communication Device, which remotely monitors the residential Conext products. "It has a webservice so all information can be accessed on a computer, website, android device or tablet. The user connects it to their solar system components. It communicates using either hard-wire or Wi-Fi bridge to the devices they choose."

For the large commercial and centralised PV plant segment, Schneider's latest offering is a UL approved inverter for thousand volt utility-scale projects. "It's called the Context XC-NA line of central inverters. It has the highest CEC and European Union efficiency ratings of any central inverter in this power range," Wodrich says. "We build integrated package solutions by pairing the inverters with medium voltage step up transformers, DC recombiner boxes, and a SCADA monitoring solution. We pre-package this offer for larger utility scale projects and employ them in blocks that are rated from 1 megawatt to 1.36 megawatts."

Meantime, catering for the full PV market spectrum (residential,

commercial and utility) is American firm **Solectria Renewables, LLC** – it has recently announced a premium efficiency 500kW SMARTGRID inverter, the SGI 500PE. At 97.5%, the transformer-based SGI 500PE boasts the highest CEC efficiency and peak efficiency (98.1%) in the solar industry, the company claims.

"We also have new Disconnecting String Combiners (DISCOM's) that allow installers, maintenance crews and first responders to turn off power near the DC source, greatly enhancing PV system safety. The disconnecting string combiners are compliant with UL 1741, CSA C22.2#107.1 and help installers meet the latest National Electric Safety Code (2011 NEC) requirements for de-energising DC output circuits," Natalie Holtgreffe, Marketing Manager says. "One of our core competencies is fewer connection points which results in less failure points and easier serviceability."

Collaborative innovation

Moving on, **Ampt LLC** and **LTi REEnergy** have recently introduced utility-scale inverters featuring "Ampt Mode" to deliver a two-thirds increase

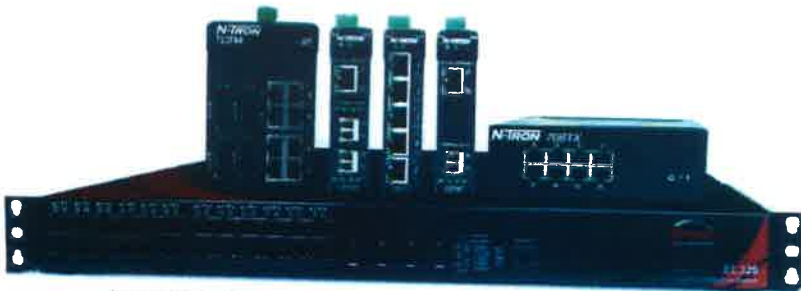
in output power and reduce PV systems costs by up to 40 percent. "Our objective is to lower the cost, and increase the performance of PV systems so solar energy is more profitable," says Levent Gun, CEO of Ampt, which is a technology company focused on DC/DC power converters that plug into solar modules.

"We develop high performance DC/AC inverters at a much higher power level and efficiency when deployed with Ampt products in a PV system," adds Steve Shirey, VP of Photovoltaics, North America for LTi REEnergy, part of the LTi Group in Germany.

Both companies are founding members of the HDPV Alliance, which recently launched to advance industry adoption of lower cost, higher performance PV systems through collaborative innovation. "If you look at HDPV as a product category, it changes the inverter architecture by distributing two broad functions. There are DC side controls for managing power from the PV modules and DC to AC controls for connecting to the electrical grid. HDPV takes the DC controls and distributes them deep into the PV system while leaving the AC functions



The LTI REEnergy PVmaster with Ampt Mode™ is in a new class of lowest cost, highest performing large-scale solar inverters. This HDPV-compliant inverter's output power rating is increased 60% when deployed Ampt DC/DC converters to lower costs by 40% while operating at greater than 98.6% CEC efficiency. Courtesy of Lti REEnergy



Red Lion technology allows wind and solar to transmit data swiftly and securely over long distances. Courtesy of Red Lion Controls



Solectria family of Inverters for all market sizes. Courtesy of Solectria Renewables

centrally managed at the inverter," Gun explains.

Ampt builds very small electronics that work as inverter helpers. "We not only get more energy out of the systems, by locally optimising the energy production of each module, but we do it in such a way that enables inverters to deliver more power from a given platform and saves overall cost."

The LTI inverter is designed to allow it to get significantly higher power out. Going from 600 kilowatts to one megawatt is a significant increase and represents a 40% cost savings. The market for HDPV compatible products is full range; residential, commercial and utility. Because of the size of the LTI inverters, Ampt works with them on larger systems, particularly ground-mount utility scale PV installations.

Tigo Energy, Los Gatos, CA USA, designs a panel level optimisation technology, which is a very small, light weight PCB that goes on the back of solar panels to optimise their power. It gives panel level intelligence and makes panels more manageable, productive and safe.

"Our optimiser utilises impedance matching to improve the performance of the module and provide module-level monitoring. It only operates when necessary, simply bypassing underperforming panels at an intelligent ratio. This gives a design with one tenth the part count of a standard micro converter," says Evan Sarkisian, Marketing Director. "We can optimise all varieties of solar that are in panel format. We work with all leading inverters on the market."

Tigo Energy has partnered with Upsolar, which has definitely moved the technology from a niche market player. According to Sarkisian, its tiny device provides electronics and intelligence directly into the module. "It ships from the Upsolar factory with the optimisation technology embedded in every panel. It's easier to install, panel to panel and it reduces the cost of the cabling from box to box.

"Traditional modules are not intelligent and they only shut down. With our system, if a panel is performing at 20% below we will bypass 20% around that panel. Our solution is based around

Power and Electronics



ODTG200US11 - solar switch. Courtesy of ABB, Inc.



The ABB LG(X) current transformer is a popular choice for North American wind farm developers. This unit features high accuracy. Courtesy of ABB, Inc.

A key player in the global market is **ABB**. The company's Medium Voltage Distribution Components Facility is located in Pinetops, NC, USA. Jon Rennie, Vice President & General Manager, is responsible for distribution, automation and components. "These are products used on sub-stations and feeders to measure current and voltage for both metering and production applications. Current and voltage instrument transformers are products that take current and voltage from dangerous levels and reduce them to safe levels to be measured."

The company's products allow utilities to accurately measure the amount of energy being generated and the amount being used from all the generation sources. "Particularly because of the fluctuation of renewable power sources such as solar and wind, accurate data on the power generation levels is extremely important for all utilities," Rennie notes.

Steve Lindsay, ABB Marketing & Sales Manager Distribution Components, adds: "We make specific instrument transformers just for wind applications. A small voltage transformer is installed in the nacelle to sense the energy that is being produced, at a very specific voltage level, 690 volts. For solar it's the same exact thing, except obviously it is not in a nacelle."

"Larger, high accuracy, extended range current transformers go into the collector substation. We can measure the load down to a very, very small level of current -- a level that competitors just can't get to."

The ABB division handling switches and circuit breakers, meanwhile, is

located in New Berlin, WI, USA. "In large solar fields, all the PV panels which are at a lower voltage/lower current, are combined and brought up to a higher voltage and a higher current for efficiency reasons. After they go through these combiners, then the power goes to the inverter to convert it from DC to AC so it can tie back into the grid," says Russell Janowski, ABB Product Manager, Low Voltage Disconnect Switches.

"We came out with a Disconnect Switch range specifically for DC solar. This is typically for larger industrial, municipal/commercial and utility size installations. A typical application where you would use these switches would be in combiner boxes and for inverters."

Thomas Leja, Product Manager for Molded Case Circuit Breakers, notes that combiners are very popular on the solar farms. "There are also recombiners that take the output from combiner boxes and combine those. In all of these combiner and recombiner boxes you need to have an isolation disconnect so if they need to go service any of the solar panels, they can disconnect them to service them safely. They install inside the actual combiner and inverter boxes. The only thing on the outside is a big on/off switch."

Leja says when ABB designed these new higher range circuit breakers, it was careful to make them installation compatible. "A designer who used our 600 VDC could upgrade to the 1000VDC without changing his design. They can use this in their inverters and combiners without needing to redesign the layout."

an algorithm that states what a panel should be doing. We are measuring every panel every two seconds. Smart modules can be installed twice as close to shade sources as traditional modules."

Red Lion Controls fits into the renewables area for both Wind and Solar with technology for utility scale. It allows both to be able to transmit data swiftly and securely over extremely long distances. Diane Davis, Director of Product Management, Networking, says, "Solar farms

and wind turbine farms are typically installed in very remote and hostile environments. They are hard to access and to maintain, particularly in wind turbines. Wind turbines are in almost continual motion, creating vibration levels than can cause bolts to become loose. Even solar panels move and tilt to follow the sun. That causes shock and vibration. Both need to be monitored to get all condition data back reliably. We provide industrial grade switches that will hold up to this very

rugged environment: scorching heat, freezing temperature and high shock and vibration levels."

In wind turbines, sensors for condition monitoring data is transmitted from a switch located at the top of the tower, usually over fiber wires going down the tower to a switch that's at the bottom. "That switch at the bottom of the tower is usually connected to the next turbine in a fiber ring. All turbines will feed back into a central monitoring station remotely," Davis says.



Tigo optimisation technology measures every panel every two seconds. Courtesy of Tigo Energy

"A solar farm is set up in a very similar manner. There is often a Red Lion switch on each solar panel itself that will tie back to a central monitoring

station controlling all of them. In both cases, the integrator typically provides the field switches and control solutions. Together we provide a total solution."

While the switches transfer information, the company's human machine interface (HMI) or digital signal processing (DSP) gather all information to give any site the ability to package up all that information and send it out to the switches that send it to the main facility, says Jeff Thornton, Director of Product Management, Software & Interface. "Protocol conversion, web serving and data logging are the big three. Protocol conversion allows different types of equipment that use different machine language to communicate in a common language platform. That's what our HMI and DSP does. DSP is just HMI without the display. Large power farms and even smaller facilities that are very remote, simply can't afford to have live crews man them. The cost would be astronomical. This is a perfect window that looks into all of what is going on at any site and reports the data continually," he concludes.

Small sophistication

Arguably the most globally known innovator of electronic components for all industries is Texas Instruments (TI) – unsurprisingly it's also active in renewables. "For renewable energy, one focus on the power side. We have other units that focus on processes and others on sensing and signal conditioning integrating circuits," explains Nagarajan Sridhar, Product Marketing Manager, Industrial/Renewable/Automotive Markets.

This division has been focusing on Analog ICs (integrated circuits) and in particular, one IC called an analog gate drive. "A gate drive is something that is used between a controller and a switch. The switch is typically a MOFSET or an IGBT (insulated gate bipolar transistor)," Sridhar says. "The IGBT is used in renewable energy applications for medium to high power solar and wind inverters, where high power inverters are used. The IGBT gate driver has certain features that are quite distinct from MOFSET gate drivers. Our gate drive is called an output stage driver."

Sridhar says this gate drive has "very high drive output capability, very fast propagation time, and the ability to handle noisy applications".

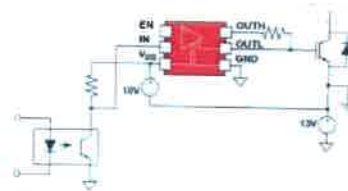
It has negative input voltage handling which is how it can handle applications in noisy environments.

"Traditionally output stage drivers have all been discrete solutions. Discrete means that it is not an integrated circuit. They have individual parts wired together. That means discrete solutions are larger and use more real estate. Also there are repeatability challenges because they are assembled parts," Sridhar says. "Controllers are getting more sophisticated and the driver must be very close to your switch and yet very far away from the controller. With a typical discrete solution that is hard to do because the real estate is quite large to get that ideal configuration."

TI's UCC27531 family of ICs are very small and can be built very close to the switch. "They also have built-in level shifting and the flexibility of an inverting and non-inverting configuration. Also, the number of devices needed within the end inverter system can be reduced. Furthermore, this family has been proven to be an effective driver solution for wide band-gap FETs solutions such as SiC."



The IGBT is used in renewable energy applications for medium to high power solar and wind inverters, where high power inverters are used. Courtesy of Texas Instruments



Split voltage application diagramme. Courtesy of Texas Instruments