inFOCUS

The mysterious met tower

Met-tower maintenance is an often-overlooked necessity in order to keep a wind farm functioning properly.

By Roger Smith

What can be 198 feet tall but be overlooked as easily as the infamous missing 10-millimeter socket?

While meteorological (met) towers are a critical part of the initial planning and assessment for energy production, there is a strong likelihood that your met tower is an unfamiliar asset and may in fact need a little TLC.

Part of the mystery surrounding the met tower could be attributed to the remote location of the met tower on the wind farm. Another possible contributor to the mystery of the met tower could be due to the relationship it has to the "money makers" — wind turbines that generate the power that creates the revenue. Another possible contributor to the mystery of the met tower could be the fact that different standards from differing agencies can apply to the mysterious met tower: FAA Regulations and Advisory Circulars, ASME Standards, OSHA requirements, ANSI Z359 for fall protection standards, tower standards (TIA/EIA 222), and IEC 61400-12-1 address the individual systems of the met tower. It can all be overwhelming to the typical wind-site manager or designee, but with a little bit of planning and communication, the mystery can be removed.

AND THE SURVEY SAYS

As a norm, wind-site managers are tasked with an enormity of responsibilities and reports. Safety, generation requirements, environmental compliance, regulatory compliance, staffing, training, conference calls, and the weekly Tidy Friday can all push the needs of the met tower to somewhere just behind weekly vehicle inspections. In other words, the silent sentinels of data acquisition can often be overlooked.

An informal survey of selected U.S. wind farms showed that many site managers were not familiar with the needs, operational status, or records regarding their site met towers. Site leadership turnover, the lack of "tribal knowledge," and all of the other duties that demand the time and attention of site leaders may attribute to this gap.

Interestingly, nearly 29 percent of those who responded to the survey stated that they had "inherited the met tower, sensors, and data loggers" and were not familiar with what type of data logger was in the met tower, and 25 percent

Periodic tower inspections and maintenance can help prevent costly repairs and help ensure accurate and reliable wind data.
(Courtesy: Cody Telford, Campbell Scientific)

of the respondents stated that the only time their team visits the met towers is when "*something was wrong.*"

Waiting until there is something wrong with your met tower can be a costly proposition. The time and cost associated with mobilizing a team, procuring materials, and notifying regulatory agencies of a failure in your met tower can be a huge investment. The safety considerations of a failed system can place your team and outside staff at an unnecessary risk. A failed met tower can create a lot of attention from land owners, regulatory agencies, press, and upper management — these items are not what you want for your week.

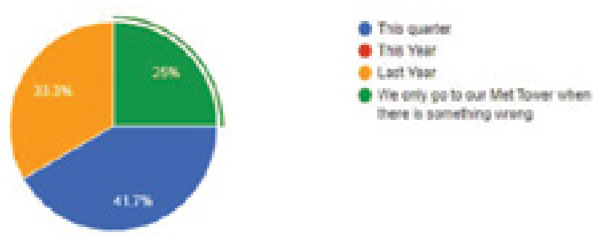
Periodic tower inspections and maintenance can help prevent costly repairs and help ensure accurate and reliable wind data. The documented inspection of all monitoring equipment, met tower structure, cabling, and grounding systems prove to be very valuable for the safe, reliable operations at your site. While tower data should always be monitored for irregularities that may indicate potential sensor or equipment failures, documenting maintenance and inspection records will help protect your wind-assessment investment and provide a historical continuity that can be extremely valuable when needed. At a minimum — a periodic, scheduled inspection and preventative maintenance regime with reliable documentation is regarded as best practice by owners, operators, and maintenance providers in this sector.

IF IT ISN'T DOCUMENTED, IT DIDN'T HAPPEN

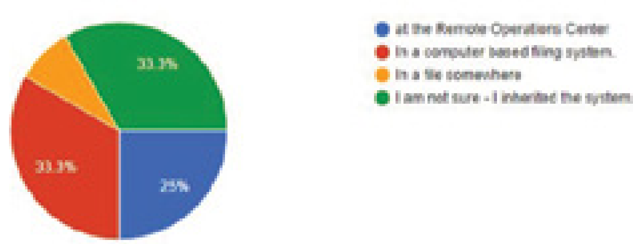
Where do you start to establish a consistent, documented inspection of the asset? What template or guideline can you use to ensure that the critical components of your met tower have been inspected and have accurately recorded that information?

A number of companies have responded to this specific need for the inspection and reporting requirements of your met tower. Sioux Falls Tower & Communication has been recognized as a great resource for the scheduled services and inspection of your system. Craig Snyder and his team at Sioux Falls can provide a thorough 145-point inspection of all components of your tower that includes a

Part of the mystery surrounding the met tower could be attributed to the remote location of the met tower on the wind farm. (Courtesy: Consertek USA)



When was the last time you conducted a "check on your met towers? (Courtesy: Campbell Scientific)



Do you have maintenance records for your met towers, if so, where do you keep the data? (Courtesy: Campbell Scientific)

Your wind-resource data is the key to your success. (Courtesy: Campbell Scientific)

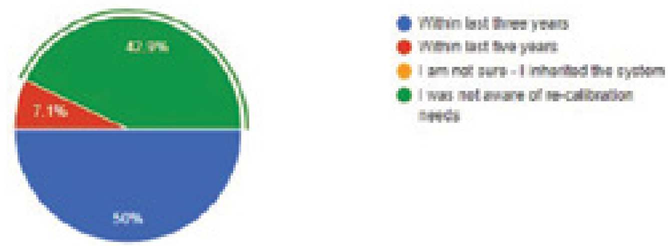
Waiting until there is something wrong with you met tower can be a costly proposition. (Courtesy: Campbell Scientific)

detailed report for your records. They provide a complete inspection of met tower foundation, (or base plate), grounding, guy wires, fasteners (bolts), safety markings, booms, sensors, and cabling and lighting. A systematic report is physically generated and provided to the site detailing specifications and images of your tower, making critical information accessible and useful when needed.

How often is this assessment to be conducted? FAA guidelines require that the lights be inspected every 24 months and that "*lamps should be replaced after being in operation for approximately 75 percent of their rated life or immediately upon failure. Flashtubes in a light unit should be replaced immediately upon failure, when the peak effective intensity falls below specification limits or when the fixture begins skipping flashes, or at the manufacturer's recommended intervals.*" (FAA Advisory Circular AC 70 7460-1L).

"Met towers are usually very durable structures," Snyder said. "Many owners are following the best practice by conducting a physical inspection of the electronic components annually and scheduling major maintenance at three-year intervals for guyed towers and a five-year cycle for self-supporting (lattice) towers, according to TIA 222."

Scheduling met tower service inspections will help protect your wind assessment investment. A regular inspection schedule of all monitoring equipment, met tower, cabling, and power supplies can prevent lost data and save you valuable time and money. The days of reacting to a met tower "emergency" by sending your best wind-turbine techs out to get the system back on line is not the best option available to you as a site leader. The met tower has a number of systems and safety concerns that the wind technician is not equipped nor trained to effectively and safely navigate. Let the technicians keep the turbines spinning; leave the met towers to the specialists.



When was the last time your loggers were calibrated? (Courtesy: Campbell Scientific)

GETTING TO THE HEART OF THE MATTER

Your wind-resource data is the key to your success. It captures and records the information of your availability and provides compliance information for offtakers. Many of our customers ask: "How often do we need to collect our data?" The answer: How much data can you afford to lose? If your data is that important — and it is — then how often do you need to calibrate your sensors and your data loggers?

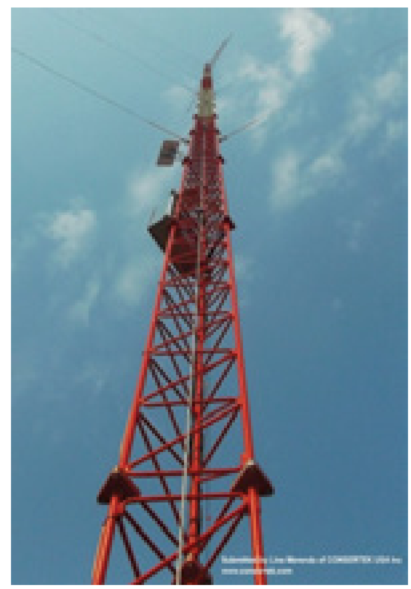
Most sensors are calibrated annually or at least every two years — and what about your data logger? Again, the survey from the field revealed a large discrepancy in calibration requirements for the heart of your data system. Nearly 43 percent of site managers were not aware of datalogger calibration schedules.

Dataloggers are the heart of your wind resource assessment system and need to be accurate and dependable under extreme conditions. While some datalogger manufacturers recommend a two-year calibration scheme, Campbell Scientific recommends a three-year cycle for calibration of their dataloggers.

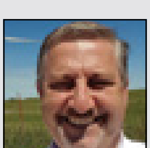
A recent study conducted and verified by a third party revealed that over a five-year period, there was virtually no "data drift" in their Campbell Scientific datalogger. The take away from this report is that you should not have to worry about measurement uncertainty. Make sure your datalogger has been tested at the manufacturer and has the calibration and, more importantly, that the data of the actual test measurements over temperature are shared with you. Follow your manufacturer recommendation and observe best practice for calibration of your datalogger.

THE SKY IS THE LIMIT

The days of knee-jerk responses to get your met tower fixed with significant resources do not need to be the norm for your wind farm. With a systematic approach, solid equipment, and good relationships with key players, you can keep your wind-resource data consistent and secure. Scheduled inspections, periodic maintenances, and a standardized documentation plan can keep your met tower down time and lead times manageable. The tower system used as the standard for your wind resources can continue to operate efficiently and provide you reliable, accurate data.



Scheduled inspections, periodic maintenances, and a standardized documentation plan can keep your met tower down time and lead times manageable. (Courtesy: Consertek USA)



Roger Smith has an MBA and is a renewables market sales manager for Campbell Scientific in Logan, Utah. Smith would like to acknowledge Craig Snyder with Sioux Falls Tower & Communication, Line Merenda with Consertek USA, and Kevin Rhodes and Cody Telford with Campbell Scientific for contributing to this article.

Students training for the final practical climb. (Courtesy: EcoTech Institute)

Aspects of wind safety

Wind technicians should be properly trained for any possible emergency scenario, so they know what to do if the need arises.

By Trent (Legend) Nylander

Safety plays a key role every day as a wind technician in the field, whether in the nacelle or on the ground. As turbines get taller and production starts to move offshore as well, what are the training aspects of safety that keep the technicians safe?

It starts with the interview process, where questions are asked to find out just how safety conscious you really are. Are you willing to put yourself in danger for the sake of the job? The clear answer is no. We want to instill a culture that safety comes first: Safety for ourselves and the safety of others. With a background as a site manager and EHS manager, I was involved with all aspects of site safety and certified in the conduction and reporting processes as OSHA began to set rules and regulations for the wind industry. But most turbine owners and manufacturers have set their own guidelines to surpass those being implemented by OSHA.

RANGE OF TRAINING

The majority of wind companies and owners have implemented a wide range of safety training for the industry. Along with GWO (Global Wind Organisation), this training assures standardized climb and rescue training on an international scale. It also establishes protocols and contingency plans that are executed and exercised on a regular basic.

No technician is allowed to climb on site until he or she has been proven and certified by an instructor as a competent climber. Levels of training start from the basics of self-rescue and first aid to more advanced rescues. The more advanced rescues scenarios include evacuating an unconscious tech from a blade or pulling a person from beneath a gearbox.

At EcoTech, we use the same industry standards to train our students for these situations daily. This is where you want them to make the potential mistakes, not for the first time on the ladder in a real emergency. One-on-one instruction on the ladders gives the instructors the insight to each student's level of proficiency and the time to refine their skills. Safety begins in the classroom and progresses as the students/technicians advance in their level of training and proficiency. Training daily in the processes of LOTO and extending the lessons with climb and rescue training, enhanced with different possible scenarios gives the feel of real life emergencies without the loss of life in the process.

As a technician, you can expect to use your knowledge of safety daily, with the numerous forms that are needed prior to starting your climb to the top, including JSAs, JHAs, PPE, Tailboards, etc. Only those properly trained for a procedure can perform said procedures. This protects man and machine alike, with personnel knowing how to respond in any unsafe situation. Upon course completion, students also receive their OSHA 30-hour card to present to their new employer showing they fully understand the hazards involved and how to mitigate them.

SAFETY 101

We teach the students Safety 101 from scratch, using industry standards and focusing on established safe practice methods. Students learn the proper use of LOTO identification and the energies we should safeguard against. With 3-phase 690-volt production, electrical energy is what we think of first when performing LOTO. But we teach them to look further into the process, such as what other types of energy we might need to safeguard ourselves against, including pressurized and stored energy, as well as gravitational forces that might come into play.

This also includes not only using the right tools for testing, but knowing you have the correct tool for the job. As the students' progress through the courses, the level of safety training increases in its complexity. Ladder rescue and self-rescue training adds another element of real life to the exercises, and students compete on proficiency and time in the rescue scenarios. They learn team work most of all; being able to work with others is an important part of being a great technician.

In the field, safety is built into everything we do, from driving the site roads to shipping hazardous materials. As site EHS manager, you are responsible for all aspects of safety on site, such as how and where to store grease and oils and proper disposal of hazardous materials, to name a few. Overseeing that tools are calibrated and PPE is inspected and in the books is another small part of the job.

SAFE WORKING ENVIRONMENT

The most important part of the job is making sure everyone has a safe working environment. This involves making sure all technicians have their training up to date and scheduling those in need of additional or refresher training.

Every technician hired undergoes a minimum of two to three weeks of training prior to climbing a tower; this includes basic LOTO and first aid, along with climb rescue training. At that point, the technician is set on task with their first crew and assignments. With a lead technician heading the crew, the new technicians are allowed to perform minor functions while shadowed by a seasoned technician. Then, when the technician has been evaluated according to the training, the decision to progress the worker to the next level of training is evaluated and/or scheduled.

Additional training is ongoing, approximately two times a year with most wind-farm own-

Students must perform a two-man pick and are graded on time and form. (Courtesy: EcoTech Institute)

ers and operators. This would consist of refresher first aid and LOTO advancements, as well as platform-specific training. Advancing technicians learn special rescue techniques that include rescuing personnel from beneath a gearbox or an unconscious victim in the blade. At EcoTech, we try to focus on the early stages of rescue, the self-rescue, two-man pick, and over the side.

Without proper schooling and training, this would be the technician's first time working on a ladder. Here we get to work with the students to refine the skills that will get them ahead in the industry. We try to condition them to keep a cool head under pressure and follow the steps they've learned in class and climbing lab. Having the climbing tower and platform make it easier for the student to observe each other's techniques. We also use video like the pros to point out what went right as well as what could have been done better.

NEW CHALLENGES

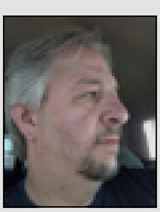
Safety in the wind industry is always expanding, and with turbines reaching unheard of heights, what new challenges lay ahead for the industry? Offshore is quickly becoming popular in the U.S., and this is new ground in the sense of safety training. We currently have an industry shortage of technicians to work onshore; how do we retrain them to fill the new need for offshore technicians?

Those who are in the industry are working with one another to set the safety guideline for what's to come. Until then, we will continue to train our technicians to focus on best safety practices including know-how and when to use safety devices and what situation calls for what measures. Our students learn to follow directions and to never skip a process. That one missed step could end up your last without proper training. Most of the fatalities in the wind industry are by undertrained subcontractors; subcontractors who are unfamiliar with wind-safety guidelines are usually the subject of unfortunate events.

The key is to properly train your employees for any possible emergency scenario, so if the need arises, they know what to do in that situation. As an instructor, we have a duty to protect our students and to make sure they can identify and isolate power in the systems.

This is where LOTO is introduced and the numerous devices for our protection. The how and when to use certain devices add to the skillset ingrained into the future technicians. We focus on giving the student the edge in the job market and add valuable skill they retain for a lifetime.

Face it, at the end of the day we all want to go home to our loved ones in one piece. If we can teach safety the right way and early enough, everyone gets to go home at the end of the night. Safety is more than a word; it's a culture and lifestyle worth living.



Trent (Legend) Nylander spent several years as a residential electrician before moving into the sales and management areas with 20 years in electrical sales and divisional management. He returned to school for a wind degree and worked as a paid tutor while attending college. Nylander graduated from Redstone College with a degree in Occupational Studies and was one of two students recruited by Siemens Wind to work on the 2.3 MW platform out of college. Within two years, he went from an entry level tech to site manager. Missing the field, Nylander went to work for Vestas and completed his initial training. After a two-year stay with Vestas, he returned home to work as a college instructor for EcoTech Institute where he has been for more than four years.

Turbine active power control systems commonly use low-power electrical drives to adjust rotor blades as needed. (Courtesy: German Ministry of the Environment)

Innovations in current transducers

Smaller, more efficient, more accurate sensors can be used for a variety of wind-turbine applications.

By John Marino

Current transducers are a key electronic component of wind-energy turbine converters. They assist the power control system, protect the drive, and help feed energy into the grid system at a controlled frequency and voltage.

Innovations in current transducer design are spurring the adoption of smart grid technologies and improving the performance of turbines and other power applications from generation and transmission to efficiency and monitoring. Improved manufacturing techniques, combined with custom ASIC chips have made it possible to achieve fluxgate-level performance from less costly closed loop Hall-effect sensors.

CURRENT TRANSDUCERS

Turbine active power control systems commonly use low-power electrical drives to adjust rotor blades as needed. As part of the converter's closed loop control, PCB-mounted current transducers are able to respond rapidly.

In the yaw control systems, transducers are continuously measuring the current order to position the drive for optimum generation. The quality and response time of these systems are influenced by the design and performance of the current transducers. The inherent advantages of closed-loop current transducers — high bandwidth, short response time, and very good linearity — makes them ideal for this application.

Closed-loop transducers also are well-suited to help deliver the electrical power from the turbine to the grid. Precise and fast current detection is necessary in order to control the power feeding back to the grid, while also monitoring the voltage of the DC link. By using the closed-loop principle, a fast response medium-current transducer can provide short-circuit protection of the power semiconductors in the inverters — an invaluable advantage for wind-energy turbines in offshore areas where the maintenance is difficult and expensive.

COMBINING HALL-EFFECT AND ASIC TECHNOLOGY

The simplest current transducers are open-loop devices in which the magnetic field from the primary current is sensed and amplified; though open-loop offset and gain can drift over extreme operating temperature.

Although closed-loop devices are more complex, they provide improved performance by canceling the primary magnetic field with a secondary compensation current in a coil of N turns. With the gain of the device set by the number of turns, N, it is precise and stable even over temperature. The transformer effect takes over the feedback loop when the primary current frequency is above a few kilohertz, providing an effective bandwidth that is much higher than the noise bandwidth. By always operating at zero magnetic field, the linearity is intrinsically good, and the response time, driven by the transformer effect, is very fast.

Closed loop transducer designs use Hall cells as the magnetically sensitive element. Hall cells provide fast and accurate current measurements but also have one weakness: the offset voltage ($V_{OUT} - V_{REF}$ with zero primary current) and its drift over temperature. One solution is to use a fluxgate detector instead of the Hall-effect chip, which improves stability over varying temperatures. However, fluxgate technology adds additional complexity and price.

Efforts to boost Hall-effect technology to fluxgate-level performance has led LEM to develop a proprietary Application Specific Integrated Circuit (ASIC) for use in closed-loop mode. In addition, the spinning technique and specialist integrated circuit used by LEM overcomes other drawbacks such as noise, start-up

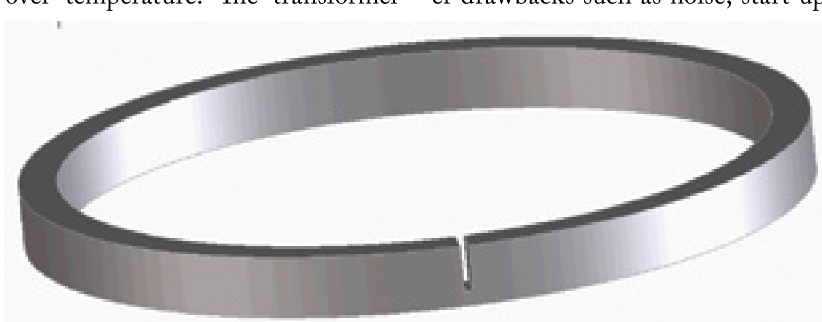


Illustration of partial air gap on closed-loop magnetic core. (Courtesy: LEM USA)

time before measuring current present on the primary, and restarting without delay after an overload.

For accurate measurement of DC currents, the technology compensates the current linkage Θ_P created by the current I_P to be measured by an opposing current linkage Θ_S created by a current I_S flowing through a known number of turns N_S to obtain:

$\Theta_P - \Theta_S = 0$ or $N_P \cdot I_P - N_S \cdot I_S = 0$

with N_P the number of primary turns and N_S the number of secondary turns.

To obtain accurate measurement, it is necessary to have a highly accurate device to measure the condition $\Theta = 0$ precisely.

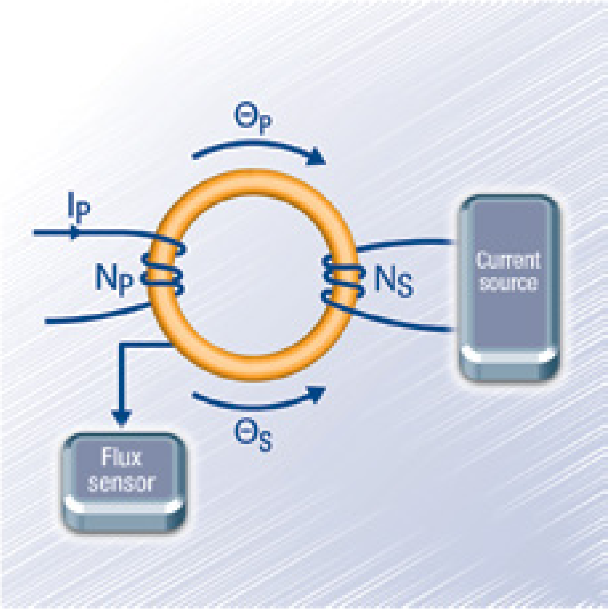
To achieve accurate compensation of the two opposing current linkages (Θ_P and Θ_S), a detector capable of accurately measuring $\Theta = 0$ must be used, which means the detector must be very sensitive to small values of a residual magnetic flux γ (created by the current linkage Θ) to achieve the greatest possible detector output signal.

Thanks to the partial air gap of the magnetic core, newer current transducers have a very low sensitivity to external AC and DC fields. This allows for a more compact design as there is practically no sensitivity to high current conductors near to the transducer. The magnetic core with a partial air gap improves the magnetic coupling and improves the response against di/dt.

The sensitivity against AC or DC fields (worst case) with ASIC enhanced technology is five times better than with the former generations using a classic Hall effect chip. The typical error with ASIC transducers is 2 percent of I_{PN} compared with 10 percent for non-ASIC current measurements when submitted to the same conditions caused by AC or DC perturbating fields.

IMPROVED PERFORMANCE

Using the closed-loop operating principle in association with ASIC, LEM has been able to achieve improved accuracy, external field sensitivity and measuring range in several current transducer designs commonly used in wind turbines.

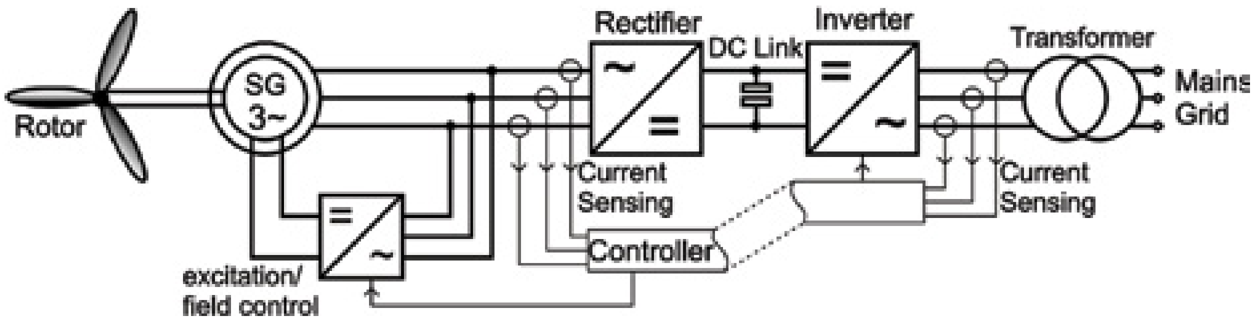


This diagram illustrates the principle behind closed-loop current transducers. (Courtesy: LEM USA)

The LF series covers nominal current measurements from 200 to 2,000A (4,000A peak) and only require a standard DC power supply range of ±11.4 to ±25.2V. Sensitivity error at +25°C is ±0.1% and linearity is only ±0.1%.

The compact, low-current LESR series is particularly well suited to applications where low offset drift is important, such as the yaw control for wind turbines or in the AC output of solar power installations where standards require a very low DC component in the output current.

In order to give the best high-frequency performance, two secondary coils wound in series are used. A special time-saving winding technique is used to avoid any soldered connections between the two coils. An on-chip memory stores corrections for any



A circuit diagram of a double-fed asynchronous wind-turbine generator. (Courtesy: LEM USA) residual offset — or other imperfections — found during the production of each transducer. Both series have excellent accuracy over their entire operating temperatures.

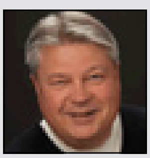
The LESR series also features a patented arrangement of multiple Hall cells in a symmetrical layout merged with the first amplifier stages, and employs sophisticated offset canceling techniques in the control loop to generates the secondary compensation current.

These improvements result in offset drift over four times smaller than previous generations of Hall-effect sensors, and very close to that of fluxgate sensors.

CONCLUSION

In the search for the increased efficiency, wind-energy systems can benefit from transducers employing ASIC technology. With high immunity to external interferences generated by adjacent currents or external perturbations, these transducers are suitable for any kind of rugged environment where good performance in terms of accuracy, gain, linearity, low initial offset, and low thermal drift is required.

Example of an ASIC (Application-Specific Integrated Circuit) for use in a current transducer. (Courtesy: LEM USA)



John Marino is the general manager of LEM USA. Based in Geneva, LEM is a leading producer of current and voltage transducers for use in drives, renewable energy, traction, and other industrial and high precision systems. For more information, go to www.lem.com.