Distribution Overhead Line Monitoring with LEM's ART Rogowski coil

New line current sensors allow utilities to monitor their overhead distribution lines to maximize their capacity and prevent clearance violations thus improving reliability and efficiency of the MV Distribution Grid.

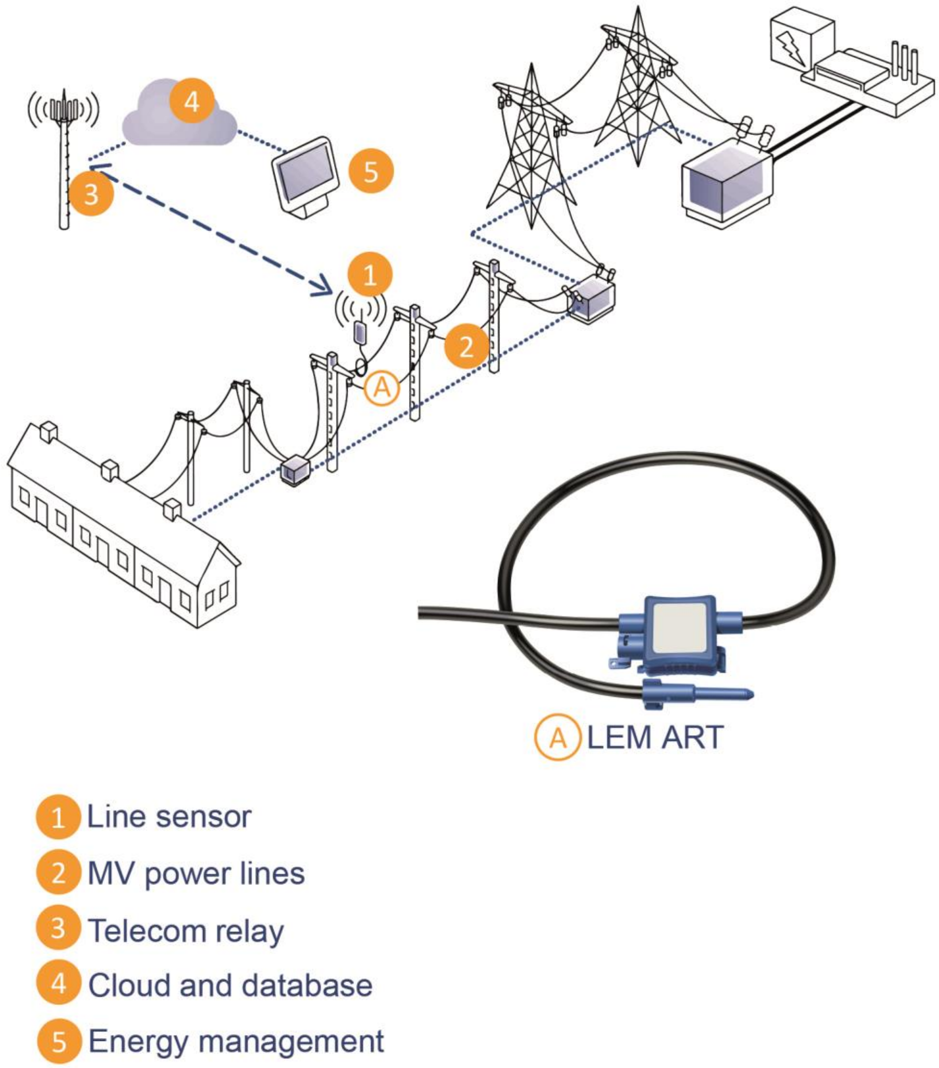
The High Voltage transmission grid is already highly automated and monitored through SCADA and Energy Management Systems. In contrast, the Medium-Low Voltage distribution grid has very limited monitoring and control. Why? - More often than not, Utilities fail to monitor their many medium voltage substations, this is due to the expense of retrofitting with today's solutions and of the time it takes to plan and build. The implementation of traditional substation monitoring requires complicated engineering, this includes the use of remote terminal units with new conduits, wiring to relays and current transformers. Engineers must schedule outages to disconnect the feeders, which takes time and may only be possible during low power consumption needs. Once the hardware has been installed, the utility has to program and integrate all the hardware into a complex SCADA system, which is a significant and difficult challenge for many utilities. There must be a better way.

Below the feeder level, remote monitoring is absent with the exception of customer billing meter points where smart meters are becoming prevalent to read, monitor and control. However, these smart meters are only collecting and communicating Voltage, Current , Power, Reactive Power, S, Energy data rather than power quality data sets like Cos (Phi), Total Harmonic Distortion, flicker, voltage dips, transients, waveforms, time series etc. The smart meter does not collect a lot of data outside of its billing focused function. Substations and distribution power lines are two of the most valuable assets for utilities that require crucial power flow data to provide the most reliable service.

The most relevant data in the distribution grid is about the location and cause of faults and non-fault events, high-impedance faults, consumption peaks, handling distributed renewable energy and EV charging, feeder outages, and many others – all high-value data that is not addressed by today's systems.

Now monitoring overhead power lines has been made possible faster, easier and cheaper with new Internet of Things telecom networks like NB-IoT and LPWAN.Thanks to a line sensor (1), installed between two MV poles (2), the grid operator can visualize, in real-time, the current flow in order to optimize the power line capacity to distribute more electricity. The wireless line sensor (1) sends data over a telecom relay (3) to a secured database in the cloud (4) or on premise. The energy management platform (5) can regulate, alert and notify the maintenance team if needed. New line sensors are now using the LEM Rogowski coil ART (A) to measure the current, detect line aging depending on the level of current, and prioritize line capacity.

A. LEM ART
1. Line Sensor
2. MV Power Lines
3. Telecom relay
4. Cloud and database
5. Energy Management



Before without visibility about the grid, the generated renewable energy distributed through an overhead line could be overloaded (red). Thanks to the three-phase line sensor system, the extra power in one of the line can be re-distributed to the adjacent lines (black) therefore reducing the initial line (blue) capacity to an acceptable level. Overall, the capacity output of the power grid is then maximized (fig. 1).

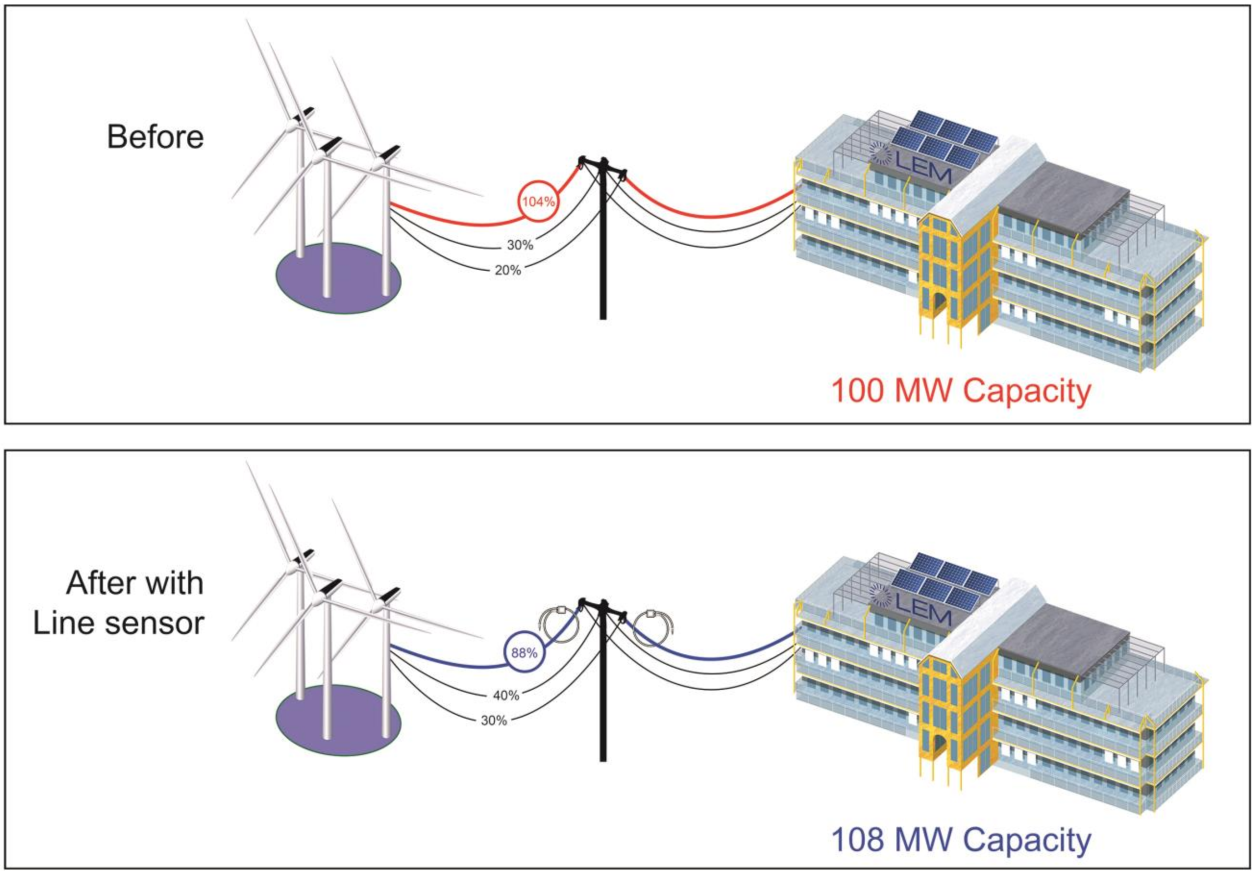


Figure 1: Before and after line sensor installation

In addition, the line sensor (1-35kV distribution grid) provides periodic time synchronized measurements to facilitate improved situational awareness and operations: current, both amplitude and phase, conductor surface temperature and detects fault conditions enabling rapid identification and notification. This three phase line sensor system in the power distribution are equalized in real-time among the different lines within a meshed network

The AC measurement can now be achieved with the LEM ART split-core rogowski coil, see below table for the summary of the ART advantages compared to two other current measurement techniques used in the Line sensor.

	Transformer inside	Resistor inside	Ferrite inside
Current sensor technology	Split-core current transformer	Split-core rogowski coil	LEM ART split-core Rogowski coil
Current range	Many versions: 80A, 100A, 300A, 400A, 600A, 800A…	One version fits all	One version fits all
Electromagnetic compatibility	N/A	*Yes (Resistor)*	N/A (Ferrite inside)
Accuracy	0.5%	*1%*	0.5%
Weight	Heavy	Light	Lightest (~100g)
Safe output of current sensor	Precaution (current output)	Safe	Safe (di/dt output)
Protection rating	IP 65 with protective housing	IP 64	IP 57
Operating temperature	-40 to +80C	-40 to +70C	-40 to +80C
PRICE	$$$	$$	$

ART is the clear winner of this comparison with a practical one size fits all current loop, excellent ferrite core, great accuracy, light, safe mV output and water resistant coil

ART Ferrite core

Recent developments have revolutionized the characteristics of ferrite at 50/60Hz, bringing many advantages. This new type of ferrite has significantly improved permeability and has been implemented in this ART Rogowski coil (fig. 2). ART takes advantage of the intrinsic ferrite qualities:

- High accuracy and excellent linearity, even at very low current levels
- No phase-shift between input and output currents
- No air gaps and virtually insensitive to ageing and temperature changes
- Low position dependent error close to the clasp of the coil (see ART Sensitivity)
- Low cost versus potentiometer based Rogowski coils

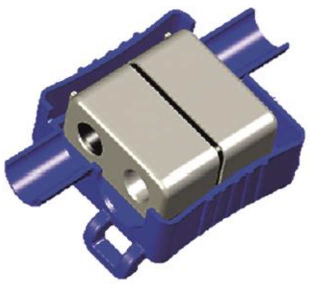


Fig. 2. Ferrite core of LEM ART Rogowski coils

ART Sensitivity

The overall sensitivity to the position of the primary conductor can be controlled, but usually close to the clasp errors are often unavoidable, except for the patented ferrite based ART Rogowski coil (fig. 3).

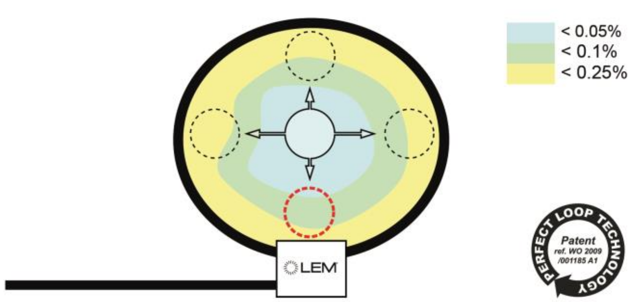


Fig. 3. Position sensitivity of ART Rogowski coil

Conclusion

The new ART rogowski coil class 0.5 has made huge progress, allowing small, light, sensitive and flexible current sensing for MV grids. The major improvements that have been made in the design and manufacturing processes have enabled a reduction in both the cost and the sensitivity to the coil positioning around the primary cable.

People consume more electricity than ever before and have an expectation that they will access their electricity without fault or interruption. The line sensor provides situational awareness along distribution feeders allowing utilities to operate and respond based on prevailing conditions. The system directs preemptive patrol and maintenance crews to the affected grid locations, enabling utilities to avoid potential short or long electricity interruptions. It reduces outage frequency, resulting in the reduction of the momentary average interruption frequency index (MAIFI) and system average interruption frequency index (SAIFI). Both indexes serve as valuable tools for evaluating a utility's performance and reliability because some countries have already put in place regulations that require a utility to reimburse customers for long electricity interruptions.

When installed with the hot stick or insulated gloves on the overhead power line, LEM ART rogowski is a safe, easy-to-install, light but robust current measurement alternative to heavy and expensive current transformers, therefore improving the overall performance, reliability and efficiency of the line sensor.

About the author

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Patrick Schuler has been working in the internet, telecommunications, smart grid, power electronics and power utility sector for more than 15 years. Since joining LEM in September 2014, Patrick has been responsible for defining the global smart grid offering and managing smart grid business development. As a smart grid expert, Patrick is a member of the IEC's world smart city community in Geneva and was the former smart grid chairman at the China European Chamber of Commerce in Beijing.

About LEM

LEM LEM is the market leader in providing innovative and high quality solutions for measuring electrical parameters for a broad range of applications in drives and welding, renewable energies and power supplies, traction, high precision, conventional and green cars businesses. LEM has production plants in Beijing (China), Geneva (Switzerland), Sofia (Bulgaria) and Tokyo (Japan). With regional sales offices near its customers' locations, the company is able to offer a seamless service around the globe. LEM is a mid-size, global company with approximately 1'450 employees worldwide and reported sales of CHF 264.5 million in financial year 2016/17. LEM City answers the demand for an accurate, reliable and easy-to-install energy sensor for future Smart Cities.

LEM City - at the heart of our planet‘s energy measurements.

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