Solar Power World

Transducer innovations are making PV systems smaller, lighter and less expensive

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When dealing with power generation, accurate measurement is key. The precise coordination needed by PV systems, smart grids and substations is made possible by the current transducers that convert electric current into usable, measurable signals. In photovoltaic installations, current transducers are critical elements of the maximum power point tracker (MPPT), inverter control and safety systems. Innovations and new materials are making the power electronics used in these systems smaller, lighter and less costly, starting with transducers themselves.

Current transducers basics

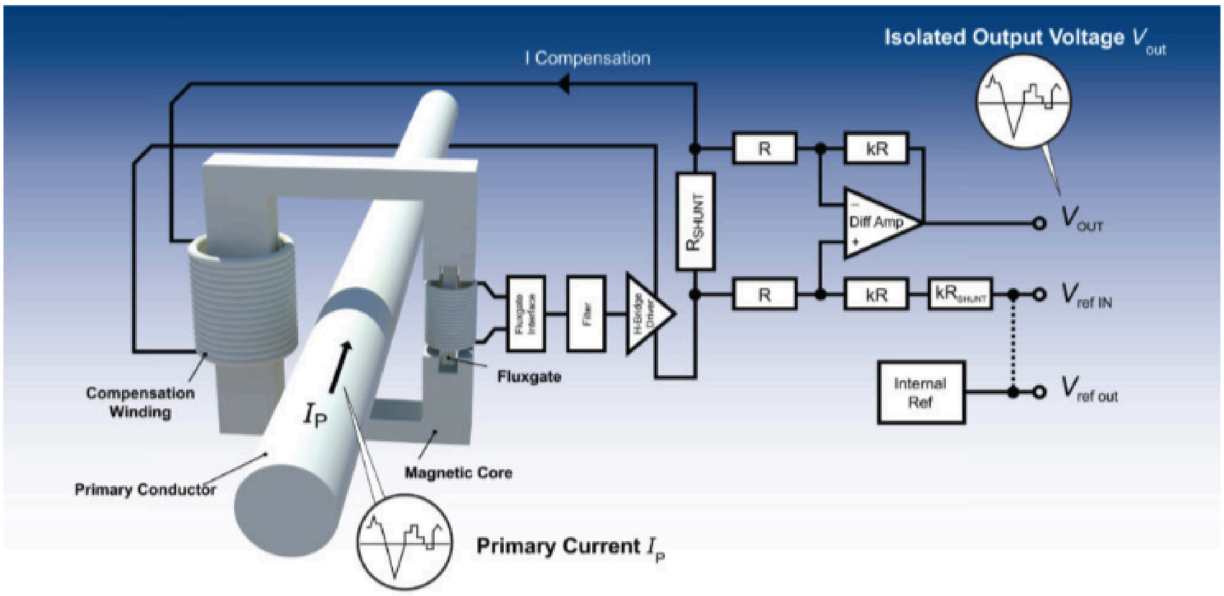
There are several different ways of sensing electrical current, and different current transducer designs for each of these. Power generation, storage and distribution systems mainly deal with Rogowski coils, current transformers, Hall effect sensors and fluxgate sensors.

Each of these technologies has its own strengths and weaknesses in terms of accuracy, range, type of current measured—as well as cost and space considerations. Rogowski coils and current transformers are frequently used in high current applications like substations and smart grid monitoring. The power electronics in PV inverters employ smaller Hall effect or fluxgate sensors.

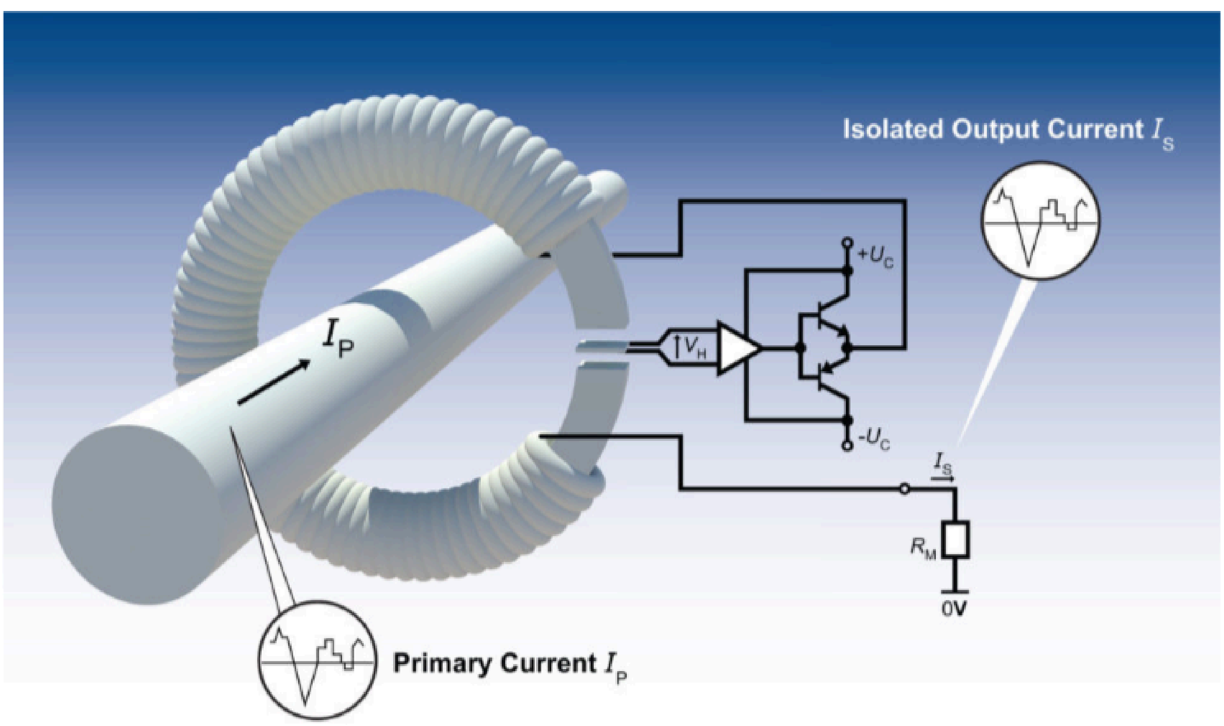
Although similar in that they work by sensing the magnetic field created by the primary current, Hall effect and fluxgate sensors have until recently offered very different performance. Fluxgate sensors offer better accuracy and stability over transformers or Hall effect sensors, and Rogowski coils are limited to measuring AC signals, but the complex design of fluxgates make them much more difficult and expensive to produce.

In contrast, Hall effect sensors are relatively easy to produce, but tend to be noisy and subject to temperature drift. They often require amplification and temperature compensation to make the output signal usable.

Recent innovations have resulted in Hall effect transducers that can achieve fluxgate-level accuracy and stability. A custom-integrated circuit takes the place of complex magnetic circuits or fluxgate components, resulting in the same level of performance but with a much simpler construction and lower cost.



Operating principle of a closed-loop fluxgate current transducer.



Operating principle of a closed-loop Hall effect current transducer.

Typically, PV installations use current transducers in three places. On the DC side, open-loop current transducers are used as part of the maximum power point tracking (MPPT) system. On the AC side, closed-loop current transducers are used both for the inverter control system and in the safety system/residual current monitors (RCM).

DC-side PV transducers

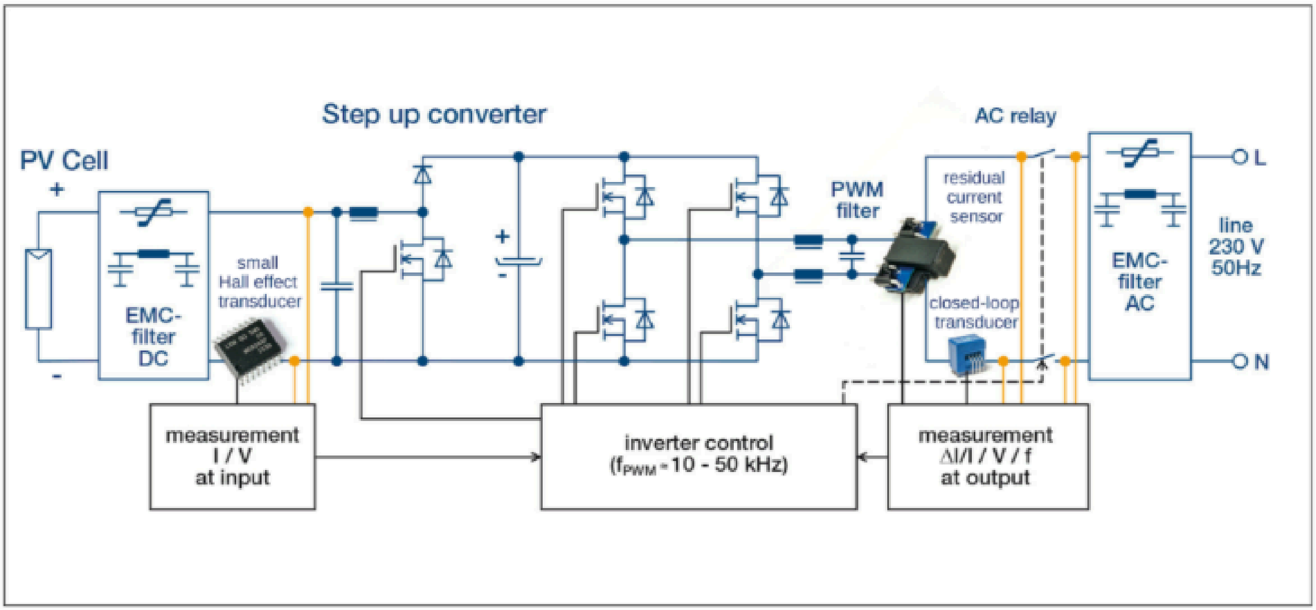
The maximum power point (MPP) of a PV panel varies based on the intensity of the sunlight hitting the panel. All the PV panels in a string have to run at the same MPP, and as long as they all have the same orientation and view of the sun, as in a residential system, the difference between the highest-performing panel and lowest-performing panel will be negligible.

However, using a single MPP for an entire utility-scale installation can severely limit the plant's efficiency. Clouds, panel placement and other factors mean the sun may be hitting panels at different intensities, forcing overall performance to drop to that of the lowest-performing panel due to the fixed MPP.

A lower cost per watt and fewer component connections has meant that central inverters have been the norm for large-scale installations. Strings of panels feed into combiner boxes, which then connect to a central inverter where the MPPT is located.

This centralized design made sense when power electronics were only able to switch at frequencies of around 20 kHz: the extra cost of installing additional inverters and MPPTs outweighed any potential efficiency savings. But over the last decade, new materials have resulted in transistors that can switch at frequencies of 50 kHz or higher. Higher frequencies mean other components like inductors and capacitors have been able to shrink in size—and because they generate less heat, a smaller heatsink is required.

All in all, a 2-kW inverter that weighed around 50 lbs in 2010 may now weigh closer to 10 lbs. Thanks to reduced costs and smaller inverters, it is now more cost-effective for many installations to use string inverters or place MPPTs at the combiner box level.



Current transducers in a basic residential PV installation.

AC-side PV transducers

On the AC side of a PV inverter, transducers help govern the accuracy of the current output waveform and the response of the residual current monitoring system (RCM). Closed-loop transducers are used for both due to their high response time and linearity.

Both applications require low offset, which has historically been met by using a complex fluxgate sensor design. But as noted earlier, Hall effect sensors using an application-specific integrated circuit (ASIC) are now able to achieve fluxgate-level low offset (and low offset drift) through a much simpler design.

Capacitance between the PV panels and ground mean that there is always some current flowing to ground, but the system must also be able to distinguish this from additional residual current caused by dangerous human contact. Current sensors with ASICs specifically designed for RCM apply a signal processing algorithm to the transducer output in order to distinguish dangerous residual current levels from ambient ones.

The current transducers may be tiny, but their importance to PV systems cannot be overlooked. Technological advances like advanced materials and programmable ASICs are improving transducer performance and by extension, reducing the cost of PV inverters and increasing the efficiency of large-scale installations.

Solar Power World Online, *LEM Transducer innovations are making PV installations smaller, Feb 2019*
https://www.solarpowerworldonline.com/2019/02/transducer-innovations-pv-systems-smaller-lighter-less-expensive/