

A Step Forward to Miniaturization for Current Sensing in Power Conversion Systems

Modern power conversion systems must simultaneously become more efficient, smaller and cheaper than previous generation. With this in mind, the Swiss company LEM, global leader in current and voltage sensing, has used its expertise in this field to create a single chip package, the HMSR.

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The traditional way to measure current is to use Open Loop Hall effect sensors. The magnetic field created by a current is captured by a magnetic core and measured by a hall element. More recently, dedicated ASICs helped to increase the overall accuracy of the system using advanced compensation techniques.

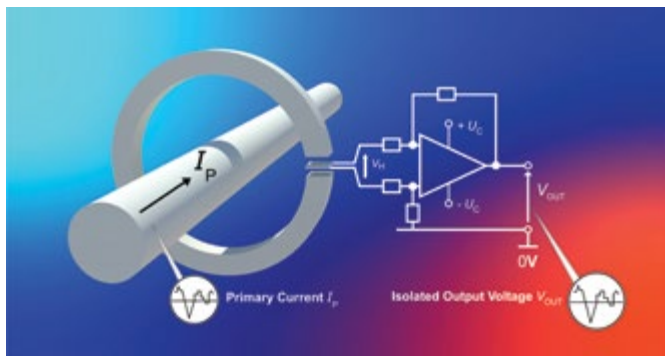


Figure 1: Open Loop technology principle using a traditional Hall effect chip or a dedicated ASIC

LEM first moved into miniaturization with the LTSR product in the previous decade. At that time, the best way to ensure optimum performances was to use Closed Loop Hall effect technology in combination with a special Closed Loop ASIC designed by LEM. The evolution of ASICs technology enabled the development of Open Loop Hall effect sensors that were capable of approaching the level of performance that Closed Loop technology delivered. Not only did Open Loop technology make it easier to reduce the size of components but it also

brought the cost improvements that the market demanded, thanks to it having a simpler structure and lower power consumption. This decade has seen the development of the HLSR series which not only delivers high performance in terms of offset and drift but also excellent response time – and all in a package small enough for PCBA-type applications with only a few mm height.

LEM has used the extensive know-how and design expertise that it has accumulated over many years to create the HMSR, a state-of-the-art current sensor which satisfies the continuous market requirements of cost reduction, performance improvements and miniaturization.



Figure 3: HMSR current sensor

With this new series, LEM is expanding its miniature, current sensors range for AC and DC isolated current measurement. The new HMSR models are easy to use because they include a low-resistance primary conductor (which minimizes power losses), a miniature ferrite and a proprietary ASIC to allow direct current measurement and consistent insulation performance.

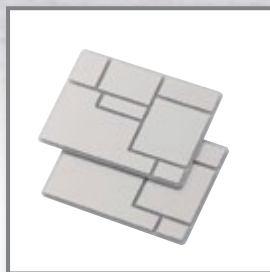
This new product category already includes six different nominal currents – 6A, 8A, 10A, 15A, 20A and 30A – with a measurement span of 2.5 times the nominal current available in a SOIC 16 “like” footprint package. Standard models provide an analogue voltage output with different sensitivity levels available, with 5V power supply versions achieving an output voltage of 800 mV @ I_{PN} .

Built-in are two OCD (over current detection) units which separate the control application path to the safety loop. These OCDs are on two dedicated pins – one set internally at $2.93 \times I_{PN}$ as threshold and one externally whose threshold can be adjusted by the user.



Figure 2: Evolution of the current sensor's size over the decades

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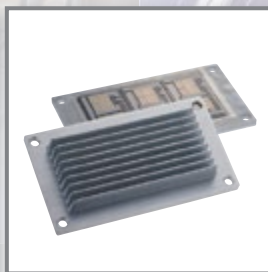
AIN-AMB Substrates

Thin-AIN-AMB substrates with lowest thermal resistance and cost efficiency in comparison to Si₃N₄ AMB substrates.



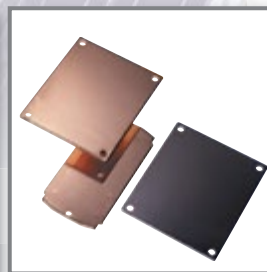
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However, HMSR sensors should not be seen as simple Open Loop Hall effect ASIC-based transducers. The HMSR unique primary conductor allows overload punctual currents and a high level of insulation. All this is combined with a ferrite-based magnetic circuit to provide excellent immunity against the external inhomogeneous fields found in power electronics applications. This enables the HMSR to be used in environments with high levels of disturbance.

The ferrite used in the HMSR is also a key factor in achieving a high-frequency bandwidth of 270 kHz (-3dB) and makes it possible to achieve good rejection against external fields.

These dedicated ASIC designs combine field-proven techniques such as spinning, programmable internal temperature compensation (EEPROM) for improved gain and offset drifts. The result is high levels of accuracy across a range of temperatures, from -40°C to +125°C with a typical value of 0.5 % of I_{PN} (the HMSR 20-SMS model). Power conversion applications such as solar inverter or drives demand high efficiency levels and these can be reached only if the control loop is accurate.

The accuracy over temperature figures have been greatly improved on the HMSR in comparison to the previous generation of products. The graph below shows the low level of typical overall error across a measured current with the HMSR 20-SMS, as well as very good linearity on a wide temperature range (-40°C to +125°C).

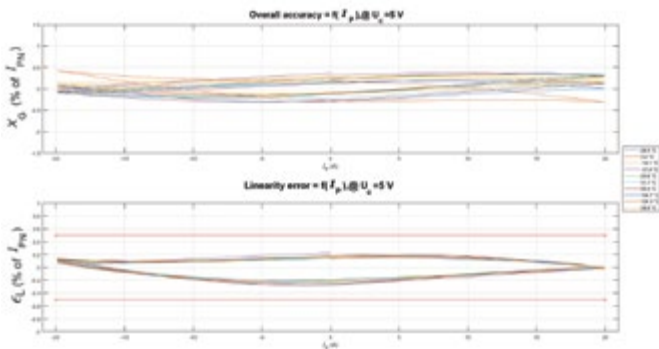


Figure 4: Typical overall accuracy and linearity for HMSR 20-SMS model from -40°C to +125°C)

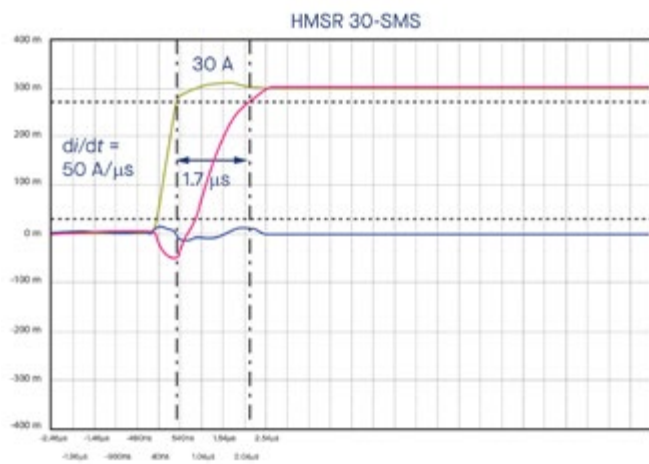


Figure 5: HMSR response time

However, such accuracy is not enough if it isn't backed by a fast response time. To this end, the deployment of a fast IGBT, like SiC-based technology, increases the possibility of working with a faster switching frequency – the HMSR is proven to be ready for such demanding technology with a response time below 2μs (see Figure 5).

In multiple applications, HMSR sensors can be mounted directly onto a printed circuit board as SO16 SMD devices, reducing manufacturing costs and providing much needed space-saving for restricted environments. At just 6mm high, the HMSR offers significant space-saving in applications, making it ideal for placing under the heatsink over intelligent power modules (IPMs) (see figure below).

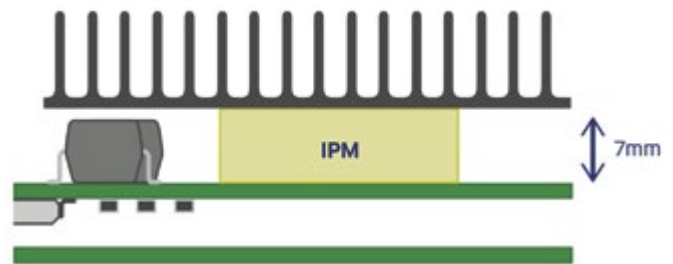


Figure 6: HMSR mounted with IPM

Another area where the HMSR will deliver significant benefits in terms of current measurement is in solar applications.

In particular, the maximum power point tracker (MPPT), an important asset in solar energy conversion, is a collection of components that maximize the power generated from a photovoltaic (PV) panel. It does this by regulating current and voltage depending on temperature, sunshine and total resistance of the system. The control system permanently analyses the system output after injecting a small perturbation (using the perturb and observe method). The MPPT then analyses the resulting power (by sensing voltage and current) and deduces the parameter to change in order to reach the MPP (maximum power point). The MPPT then changes the pulse width modulation (PWM) to adapt the voltage of the DC/DC converter.

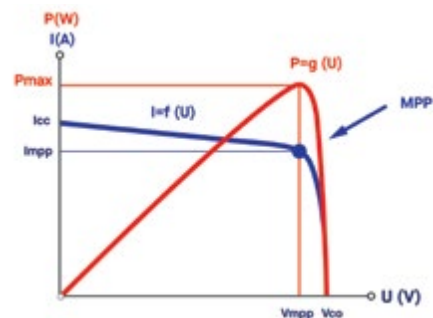


Figure 7: Maximum Power Point

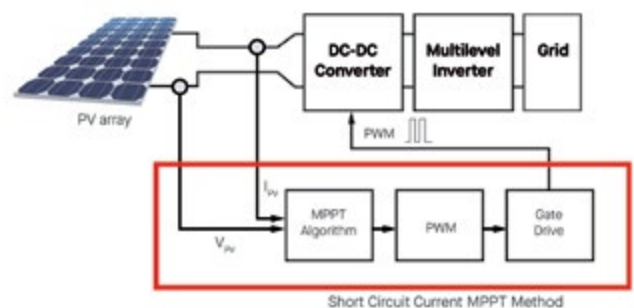


Figure 8: MPPT architecture