Application note

IMC-Hall® for low currents

Melexis
INNOVATION WITH HEART

Contents

1 Introduction

Nowadays, the current sensing function is becoming increasingly adopted in power electronics and power distribution, with the aim to control, monitor and/or diagnose electrical systems. The control function is there for conversion systems such AC/DC, DCDC, and DC/AC converters. The monitoring relates to power distribution in general. Finally, the diagnosis function is linked to the detection of anomalies that require either immediate action for protection against hazardous situations (overcurrent, …) or to detect malfunctioning and failures, to react fast and place the system in a safe state.

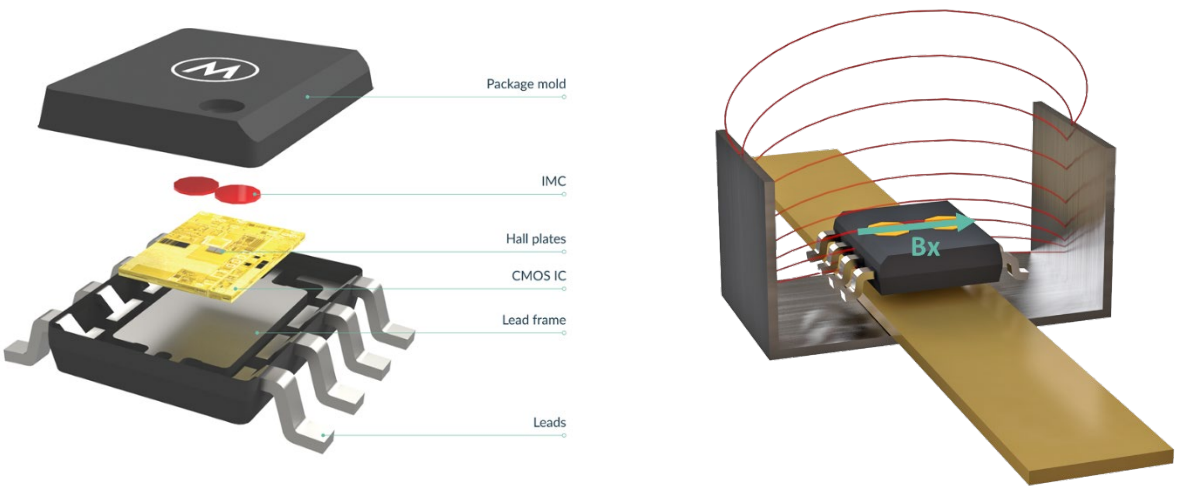
In many cases, the currents needed to be measured are relatively small (below 100A), but additional requirements such as voltage isolation, surge current capability, non-intrusiveness of the measurement, make the search for a current sensing solution not trivial. Designers need to factor in a plethora of requirements and constraints which makes it difficult to maintain the overview of the pros and cons of each technology. This application note aims to provide a good comparison between different current sensing options on the grounds of a few Key Performance Indicators (KPIs) such as the field factor, the ability to measure AC & DC currents, the mechanical integration, the type of conductor and the susceptibility to stray fields and crosstalk.

Melexis proposes different solutions based on the wide portfolio of current sensors, supporting the various requirements linked to a given application. Among these, the IMC sensors are a versatile option.

2 IMC: a reliable solution for planar current sensing

Melexis has a 20 years' experience with IMC (Integrated Magnetic Concentrators) current sensors, being the first solution enabling hall effect sensing of in-plane magnetic fields.

Compared to other in-plane sensing technologies, IMC allows **reliable sensors over lifetime** (at the same performance of hall effect sensors), with **controlled offset** and **stable performances over temperature**. These sensors are also solid against overcurrent events that would not damage the sensing element. Figure 1 describes the structure of an IMC sensor, showing the magnetic concentrators in the package, on top of the hall plates. The concentrators have 2 roles: to bend the magnetic field so that it is detectable by the hall plates, and to amplify it.



(a) (b)

Figure 1: (a) exploded view of an IMC sensor and (b) sensing direction of a general IMC sensor.

Melexis developed different types of IMC versions, covering different field full scales, as shown in Figure 2 (including also the magnetic gain).

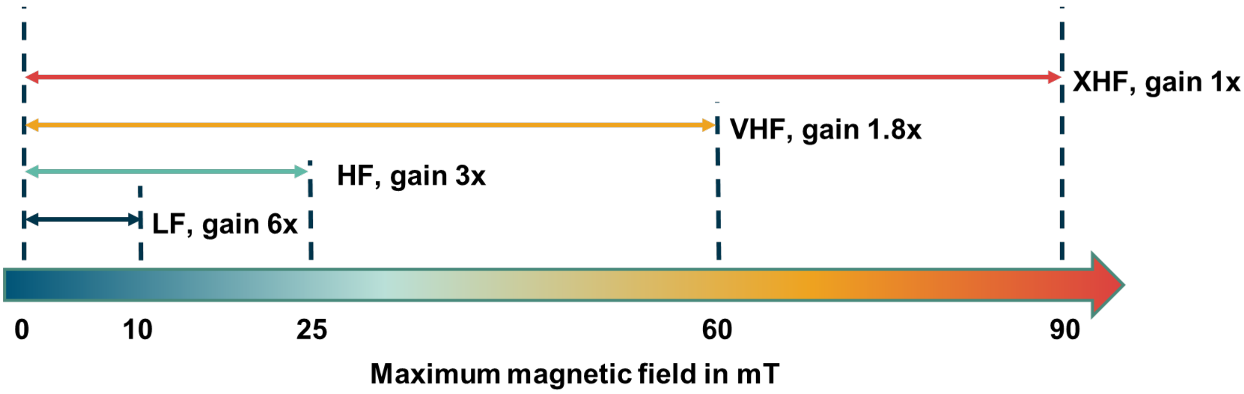


Figure 2: IMC magnetic field coverage and gain for different types.

Melexis portfolio includes different generations of current sensors, implementing all IMC types. The new sensor MLX91218 with IMC type LF, introduces state of the art performances, allowing to boost the sensitivity to up to 600mV/mT with a very large signal to noise ratio. This sensor can be used in different applications, enabling non-intrusive current sensing for currents smaller than 100A.

3 Applications for Low Field IMC sensors

Low field IMC sensors can be used for a wide range of different applications, for instance: systems requiring low current measurement but with risk of very high surge current events, systems requiring non-intrusive, clamp-on solutions, or systems requiring non-intrusive, shield less sensing.

3.1 Low current measurement, high surge currents with ferromagnetic shield

In some applications, such as for instance chargers, currents at the AC input are below 100A (for instance, 80A peak value). However, in such systems very high surge current events could occur, at current levels that can be above 1.5kA for more than 10ms. These are challenging conditions for many current sensing solutions, but optimal for the low field IMC sensor. Figure 3 shows an example of how this sensor can be simply integrated on a PCB, and by means of a shield with a width of 12mm, accurately measure the current, allowing still a wide conductor able to withstand large surge currents. The use of the shield guarantees protection against external magnetic fields, and improvement of the signal to noise ratio.

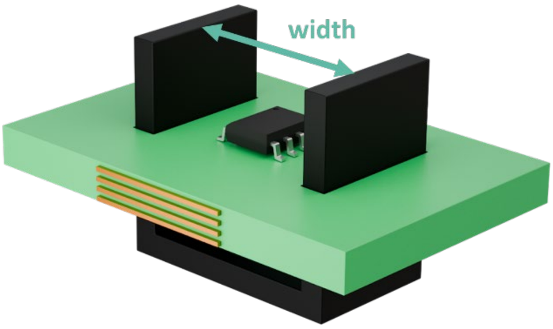
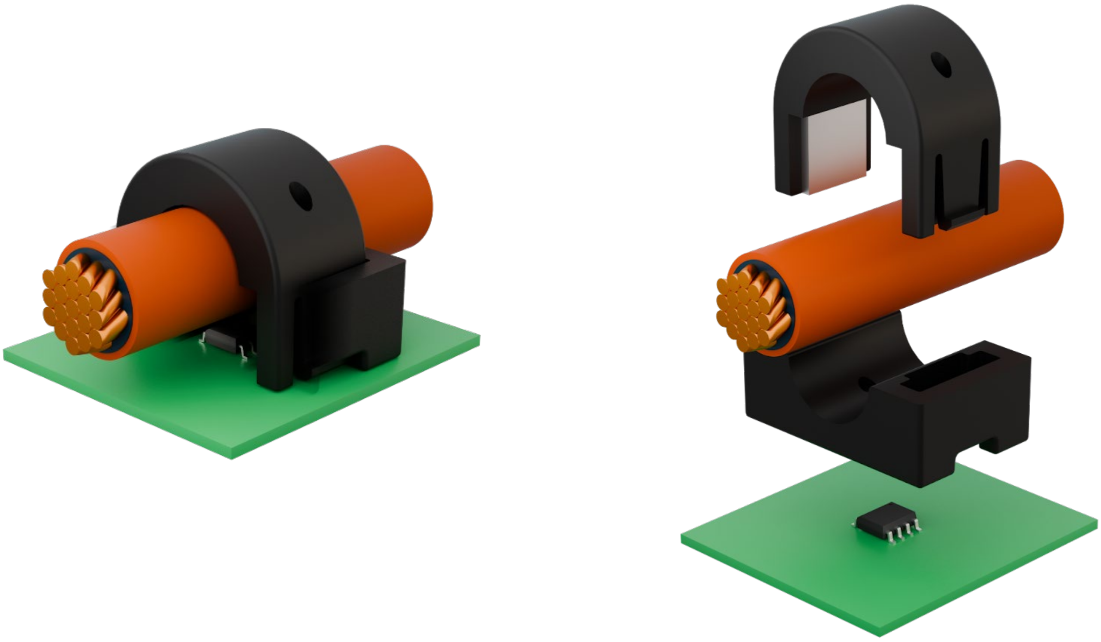


Figure 3: Use of IMC with shield for measuring currents on PCB traces.

3.2 Non-intrusive measurements with clamp-on[1]

When needing to update an existing infrastructure, introducing smart current monitoring, a non-intrusive solution can help avoiding expensive maintenance operations. One example of this is the clamp-on, consisting in a 2 parts ferromagnetic concentrator, one on a flat surface, another on a U-shape clamp, that once closed around a wire, allows to accurately measure the current flowing inside it, enabling measurement of currents as low as ampere range (see Figure 4).



(a) (b)

Figure 4: (a) clamp on solution and (b) exploded view.

[1] Source: CTS

3.3 Non-intrusive measurements, shield-less

In some applications, simply measuring the current without the need of a ferromagnetic concentrator is a possibility. In this case, the low field IMC sensor can be placed on top of the conductive trace or wire, to obtain non-intrusive information about the current (see Figure 5).

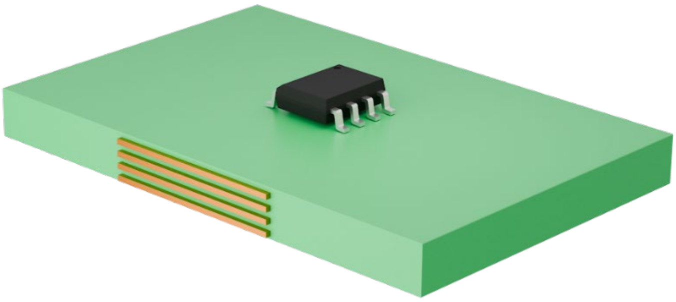


Figure 5: shield-less solution with IMC sensor.

However, this solution is subjected to the influence of other horizontal magnetic fields present in the environment: the IC will measure the totality of the horizontal magnetic field, which is the sum of the one generated by the current underneath and the stray fields originating from permanent magnets, inductances, nearby current traces and finally also the earth magnetic field.

4 Conclusions

In this application note, we discussed different solutions to measure currents, below 100A, using the Melexis IMC technology. In Table 1 we can find these solutions compared.

Sensing configuration	Conductor type	Smallest Conductor width	Field Factor	Largest magnetic sensitivity	Minimum full-scale current	Stray field immunity
IMC – Shield	PCB trace	10 mm	110 µT/A	600 mV/mT	30 A	16
IMC – Clamp-on	Wire	N/A	280 µT/A[2]	600 mV/mT	12 A	>16
IMC – Shield less	PCB trace	10 mm	56 µT/A	600 mV/mT	60 A	1

Table 1: Comparison between different technologies available at Melexis.

The following list clarifies the naming used in Table 1.

- **Sensing configuration:** this is the configuration considered, as described in section 3.
- **Conductor type:** this is the type of conductor that is used in the specific configuration.
- **Smallest conductor width:** this is the smallest dimension of the current conductor, in proximity of the sensor. For instance, this is 3mm for MLX91235 in Figure X.
- **Field Factor:** this parameter represents the coupling between the magnetic field and the current. It expresses how many µT of magnetic field are generated per Ampere of current, for a specific sensor configuration.
- **Largest Magnetic Sensitivity:** this is the maximum magnetic sensitivity achievable on a sensor. This is sensor specific.
- **Minimum full-scale current:** this is the minimum full scale current that we can achieve. This is calculated considering a full-scale analog output of 2000mV.
- **Stray field immunity:** this parameter represents how much an external stray field, in the sensing direction, is rejected from the measurements. This is computed as the ratio between the stray field value and the field that reaches the sensor. If the stray field immunity is 16, and the external field is 1mT, the sensor will only measure 63µT.

Overall, comparing these 3 options, we see that:

- **IMC – Shield:** optimal for PCB traces and bus bars measurements, with high stray field immunity and signal to noise ratio, requiring the use of a ferromagnetic shield.
- **IMC – Clamp-on:** optimal for non-intrusive measurements of current flowing in wires, for instance for upgrading existing systems giving them new functions for smart current monitoring.
- **IMC – Shield less:** depending on the external magnetic environment, this solution can be a valuable low-cost option. However, it should be clear that such a device will measure both the external magnetic fields and the magnetic field generated by the measurement current with the same accuracy.

5 Revision history

Revision	Date	Change history
001	27/03/2025	First version

Table 2: Revision history

[2] Source: CTS

6 Disclaimer

IATF 16949 and ISO 14001 Certified

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