

Non-Intrusive "Clamp-On" Current Sensor

Design – Realization – Experimental Results

1. Scope

This application note introduces the concept of the novel "Clamp-On" shield. Thereafter the design and realization of current sensors based on the "Clamp-On" shield are presented. Finally, the measurement results demonstrate the capability to build highly sensitive and ultra compact current sensors.

2. "Clamp-On" Shield

The novel "Clamp-On" shield is the result of a continuous successful collaboration between maglab and Melexis. The shield is typically combined with a current conductor and a magnetic field sensor forming a contactless current sensor. The use of annealed NiFe soft ferromagnetic material ensures superior characteristics such as high linearity along with an excellent shielding from external stray fields.

2.1 Concept

The "Clamp-On" shield consists of two distinct parts, a bottom part and a top part which are both molded into plastic packages, as shown in Fig. 1.

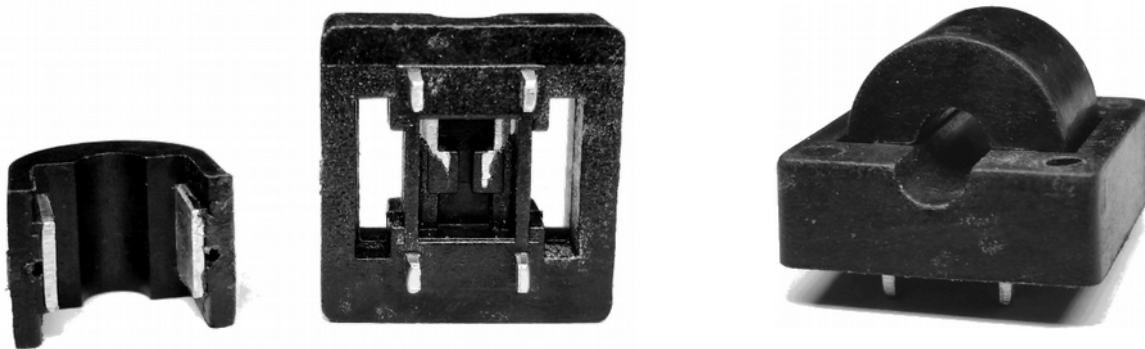


Fig. 1: Top and bottom shield parts and shield assembly

2.1.1 Assembly

The bottom part is assembled onto the PCB together with the magnetic field sensor. In the final application the current conductor is placed between the bottom and the top parts. Therefore the "Clamp-On" shield greatly simplifies the placement of the current sensor on the conductor. It provides an easy and safe installation without breaking the power line, as illustrated in Fig. 2.

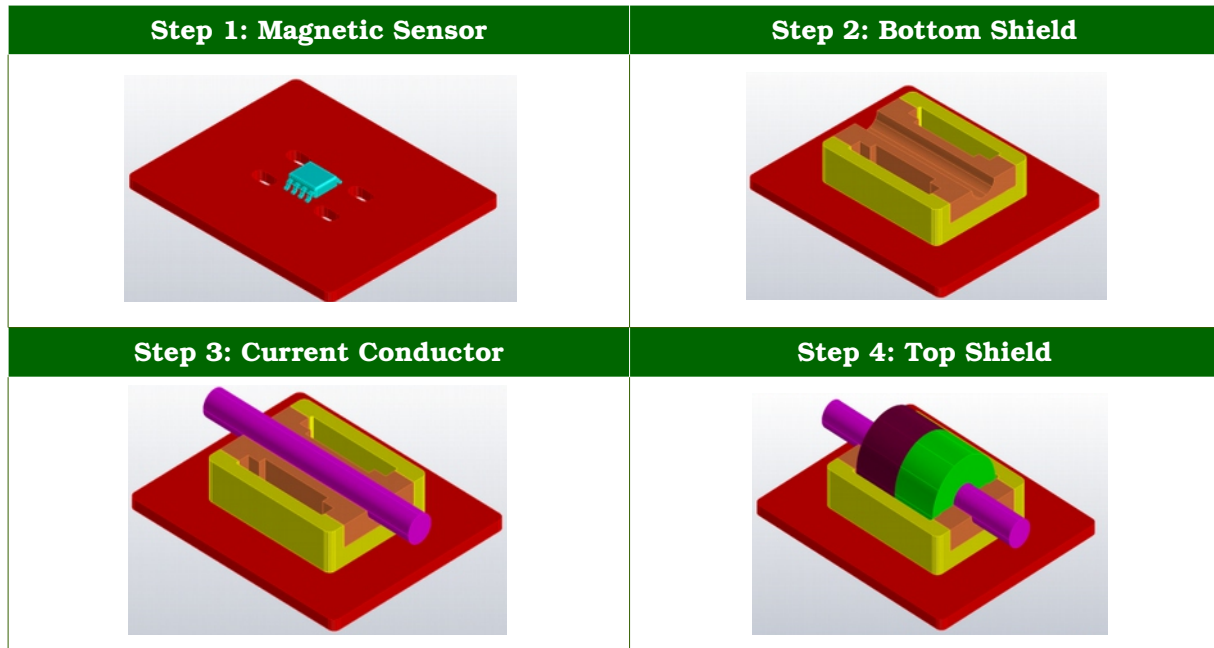


Fig. 2: Illustration of the "Clamp-On" shield concept.

2.2 Design

The "Clamp-On" shield is available in four models determined by the cable diameter and the range of primary input current, as summarized in Table 1.

Table 1: Summary of available models of the "Clamp-On" shield.

Model	Current Range	Cable Diameter
CO-4-0.8	±5 A ... ±60 A	≤4 mm
CO-10-0.8		≤10 mm
CO-4-1.2	±60 A ... ±150 A	≤4 mm
CO-10-1.2		≤10 mm

The different cable diameters result in different footprints on the PCB. The size of the models allowing cable diameters up to 4 mm is shown in Fig. 3.

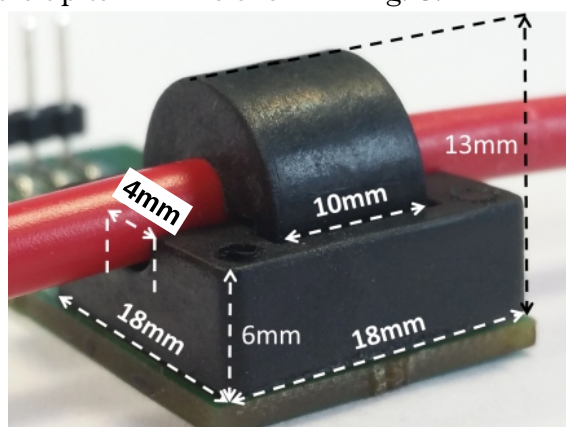


Fig. 3: Size of the CO-4-0.8 "Clamp-On" shield assembled onto a PCB

The drawings of the shield models are shown in the Appendix.

The range of primary input current is mainly determined by the small airgap concentrating the magnetic flux into the magnetic field sensor. Thereby the models for input currents of up to ± 60 A and up to ± 150 A are designed with airgaps of 0.8 mm and 1.2 mm, respectively, as shown in the shield cross-section in Fig. 4.

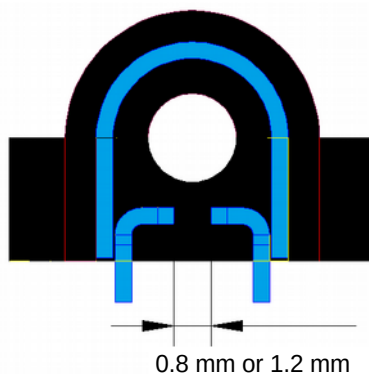


Fig. 4: Shield cross-section indicating the airgaps of 0.8 mm and 1.2 mm.

Exceeding the range of input current leads to increased non-linearity due to the partial saturation of the ferromagnetic shield. However, no permanent effects are caused. Therefore the shield entirely recovers from any magnetic exposure or over-current.

3. "Clamp-On" Current Sensor

In this section two current sensors for current ranges of ± 10 A and ± 150 A, both based on the novel "Clamp-On" shield are presented. Currently, models for ± 10 A, ± 30 A, ± 60 A, and ± 150 A have been designed and realized in collaboration with Melexis. They are available as evaluation boards. Orders can be placed via info@maglab.ch.

3.1 ± 10 A "Clamp-On" Current Sensor

Typical Applications

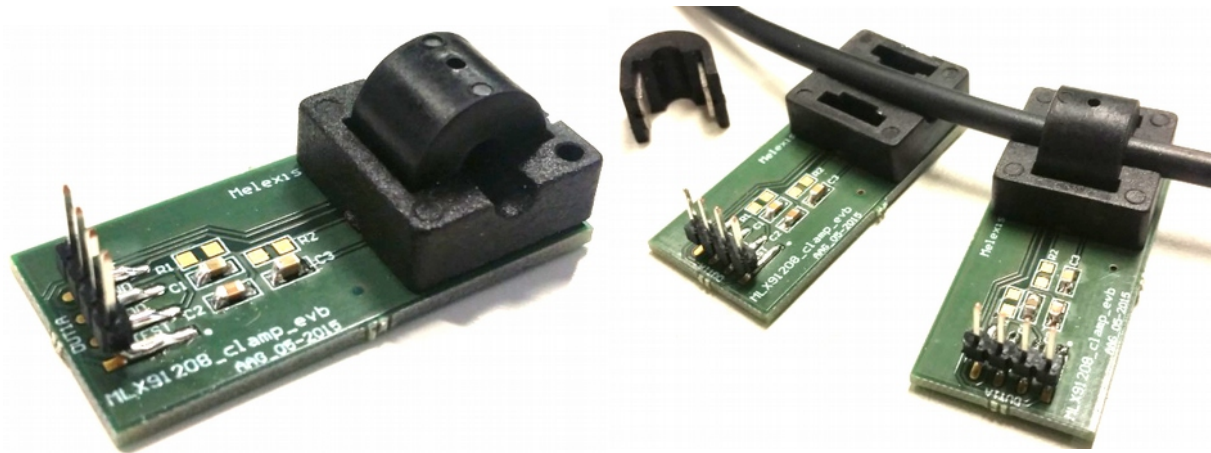
- Power line current sensor
- Energy / smart meter
- Home appliances and white goods

3.1.1 Current sensor design

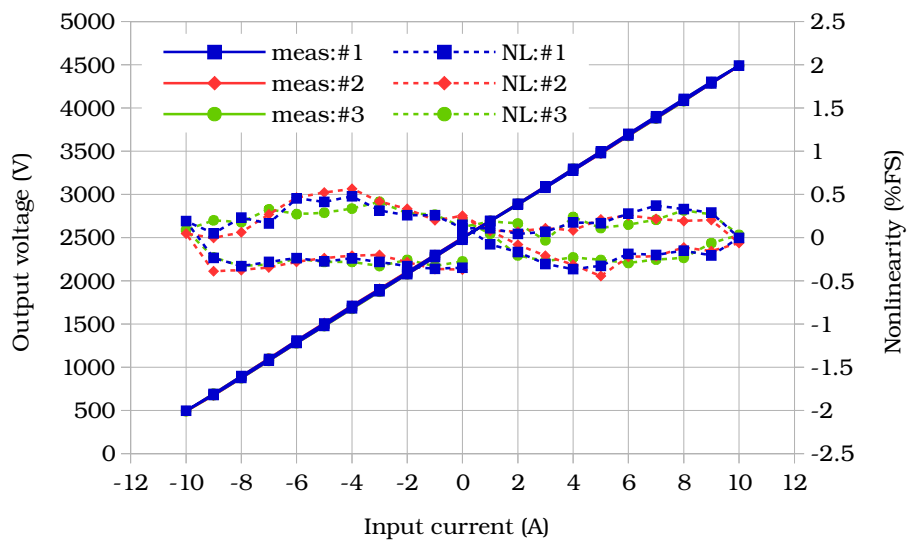
Table 2: Summary of the specifications of the ± 10 A "Clamp-On" current sensor

Parameter	Typical Value	Unit
Input Current Range	± 10	A
Output Voltage	± 2	V
Sensitivity	0.2	V/A
Non-linearity	± 1	%
Cable Diameter	≤ 4	mm

3.1.2 Realization



3.1.3 Experimental Results



3.2 ±150 A "Clamp-On" Current Sensor

Typical Applications

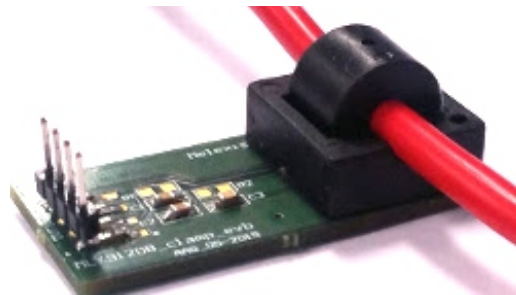
- Battery current sensor
- Battery / charge management
- Energy / smart meter
- Solar power

3.2.1 Current sensor design

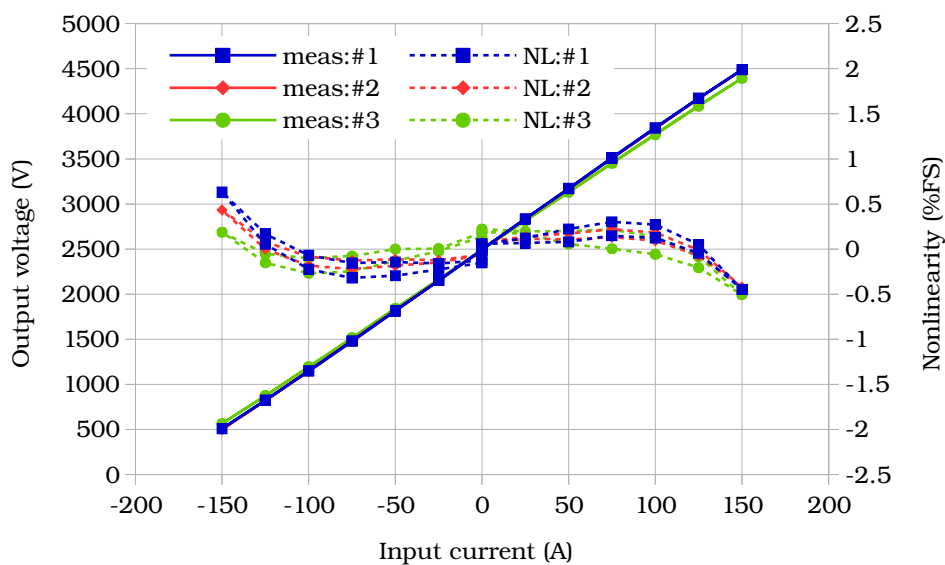
Table 3: Summary of the specifications of the ±150 A "Clamp-On" current sensor

Parameter	Typical Value	Unit
Input Current Range	±150	A
Output Voltage	±2	V
Sensitivity	13.3	mV/A
Non-linearity	±0.5	%
Cable Diameter	≤4	mm

3.2.2 Realization



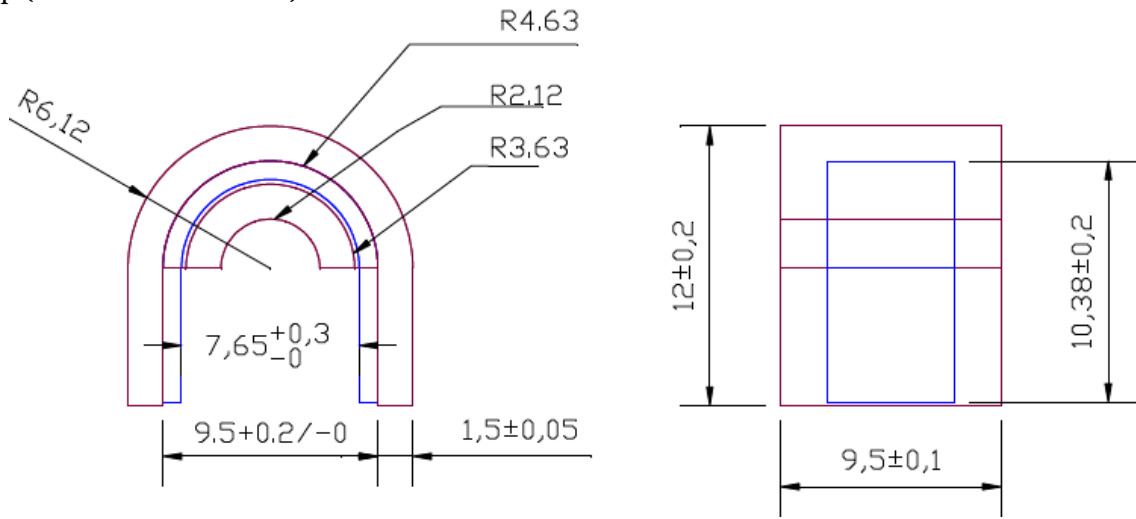
3.2.3 Experimental Results



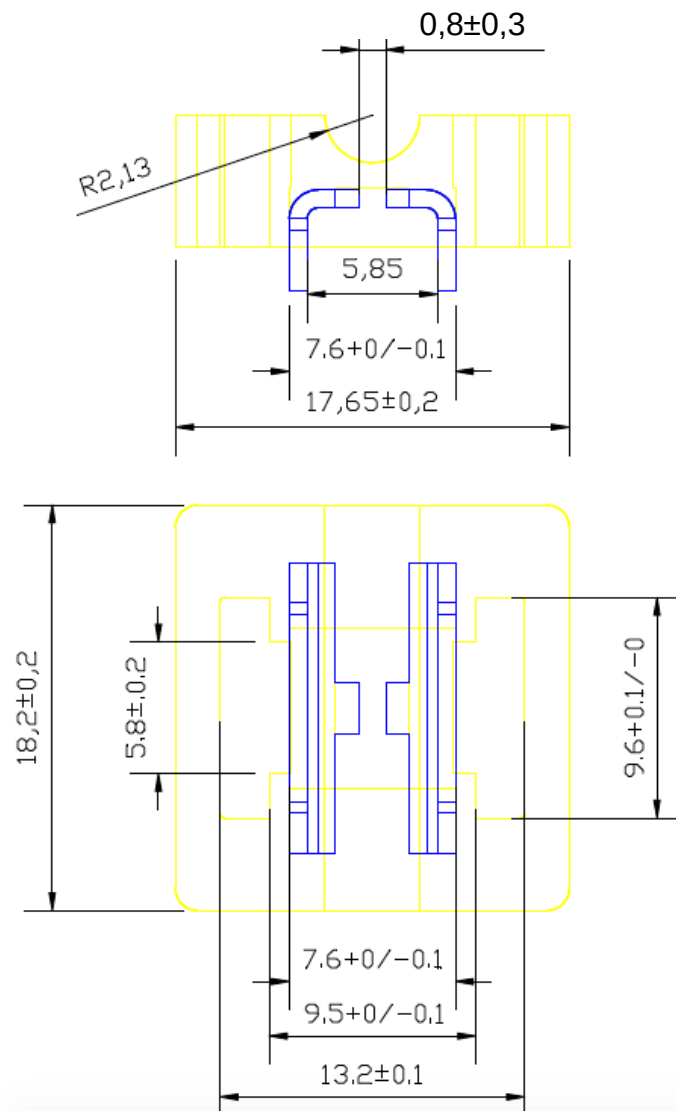
Appendix: Drawings of the Shield Geometries

CO-4-0.8

Top (all dimensions: mm)

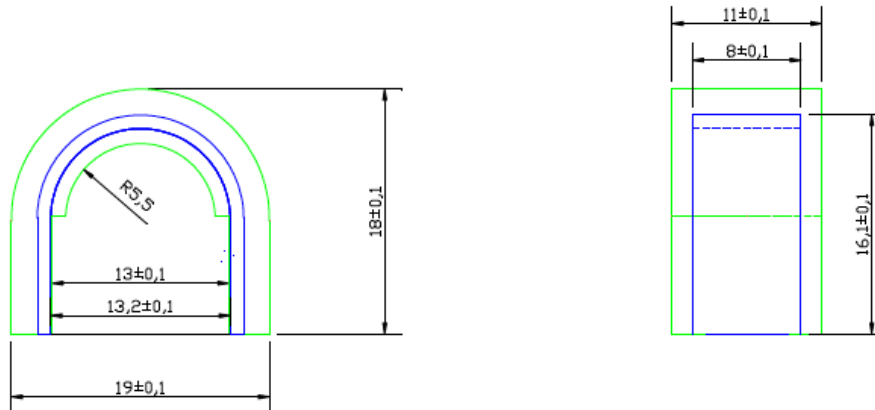


Bottom (all dimensions: mm)

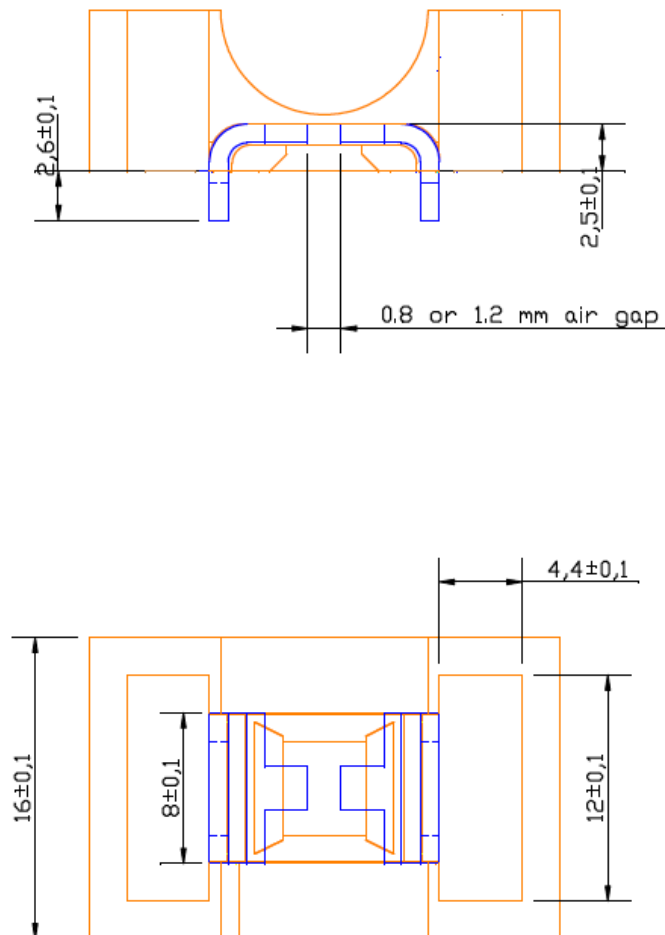


CO-10-1.2

Top (all dimensions: mm)



Bottom (all dimensions: mm)



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