New Miniaturised Transducers for PCB-based Current Measurement

LEM introduces Minisens, a miniature, integrated circuit transducer for AC and DC isolated current measurement up to 100kHz. This new component offers full isolation (no optocouplers required) and high sensitivity (from 20 to 200mV per Amp of primary current) with no insertion losses. The SO8 SMD device can be mounted directly onto a printed circuit board. **LEM, Geneva, Switzerland**

Minisens integrates, within one mixed signal ASIC, Hall-effect sensors with a magnetic concentrator to allow direct current measurement proportional to the magnetic field without the need for an additional magnetic core. If the current is bidirectional, the polarity of the magnetic field will be sensed and a positive or negative output voltage relative to the reference voltage will be generated. The non-contact measurement enables an almost unlimited current level as it eliminates the need for current to flow through the device. The only limiting factor is the thermal capacity of the primary conductor. The current can be carried either by a track (or tracks) located on a PCB underneath the Minisens, or by a cable or bus bar under or above the IC. The design for the primary conductor allow current measurement up to 70A or higher, either DC, AC, pulsed or mixed.

Many parameters of the ASIC can be configured by on-chip non-volatile memory: adjustment of the transducer's gain, offset, polarity, temperature drift and gain algorithm (proportional to, or independent of V_{DD}). Two outputs, one filtered to limit the noise bandwidth; and one unfiltered with a response time of less than 3µs are available. The degree of electrical isolation and output sensitivity can be increased by the PCB design – for example, a primary track on the opposite side of the IC gives best isolation; a track on the same side gives the highest sensitivity.

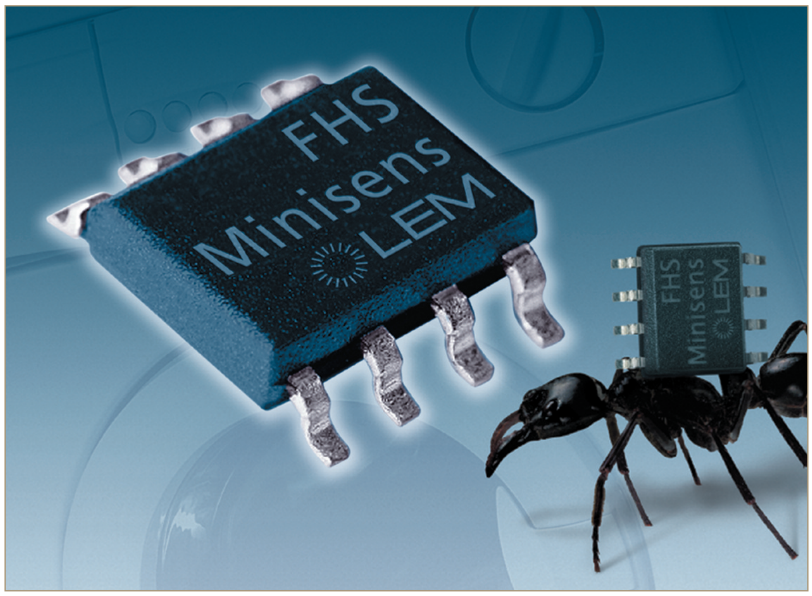


Figure 1: The SO-8 IC Minisens measure up to 70A and can be soldered directly onto a PCB

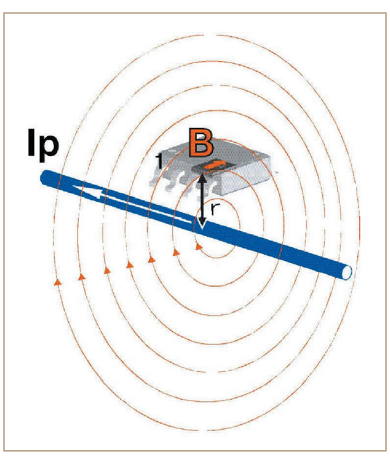


Figure 2: Minisens orientation to measure the magnetic field generated by a magnetic field by a current along a conductor

The Minisens operates from a single 5V supply. To minimise power consumption, an optional input pin can be used to switch the device into standby mode. The transducer is manufactured with a CMOS process.

Measurement with a long thin conductor

A current flowing in a long thin conductor generates a flux density around it (Figure 2) according to equation 1

$$B = \frac{\mu_0}{2\pi} \cdot \frac{I_P}{r} \ (\mathrm{T}) \quad (1)$$

Where I_P is the current to be measured (A), r the distance from the centre of the wire (m), and μ_0 the permeability of vacuum (physical constant = 4 π 10^{-7} H/m).

If the sensor is now placed in the vicinity of the conductor (with its sensitivity direction colinear to the flux density B), it will sense the flux density and the output voltage will be (equation 2)

$$V_s = G \cdot B = G \cdot \frac{\mu_0}{2\pi} \cdot \frac{I_P}{r} = 1.2 \cdot 10^{-4} \cdot \frac{I_P}{r} \ (\mathrm{V}) \quad (2)$$

where G is the Minisens magnetic sensitivity (600 V/T), the sensitivity is therefore according to equation 3

$$G_I = \frac{V_S}{I_P} = \frac{1.2 \cdot 10^{-4}}{r} \ (\mathrm{V/A}) \quad (3)$$

Figure 3 shows how the output voltage decreases when r increases (the sensitivity also depends on the primary conductor shape). This example is of limited practical use, as most conductors are not round and thin.

The measuring range limit I_{pm} is reached when the output voltage $V_{out} - V_{ref}$ reaches 2V. This limit is due to the electrical saturation of the output amplifier. The input current or field may be increased above this limit without risk for the circuit. The maximum current that can be continuously applied applied to the transducer (I_{pm}) is only limited by the primary conductor carrying capacity.

The use of Minisens to mesure a current flowing in a track provides isolation by PCB, stable and reproducible sensitivity, inexpensive design, and large input currents (Figure 4). The maximum current that can be safely applied continuously is determined by the temperature rise of the track, a track with varying width gives the best combination of sensitivity and track temperature rise.

Several factors influence the output accuracy, i.e. the sensitivity of the sensor, the distance and shape of the primary conductor, the circuit output offset and its non-linearity, and stray fields.

The sensitivity of the Minisens FHS 40-P/SP600 is calibrated during production at 600 V/T ± 3%. Movement of the primary conductor or the PCB should be therefore avoided. The magnetic fields generated by neighbouring conductors, the earth's magnetic field or magnets are also measured if they have a component in the direction to which Minisens is sensitive. But the stronger the magnetic field generated by the primary current, the smaller the influence of stray fields and offset. The primary conductor should therefore be designed to maximise the output voltage. Other Minisens versions are available for in-circuit calibration, allowing cancellation of all sensitivity errors due to calibration, primary conductor shape and primary conductor distance. For rapid prototyping, six evaluation kits for low and high isolation applications are available (see Figure 5).

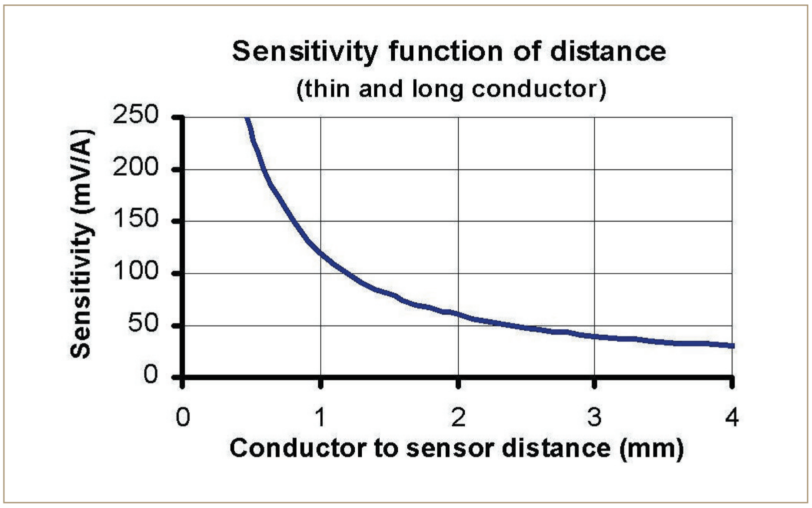


Figure 3: Sensitivity versus the distance between the conductor and the sensing element

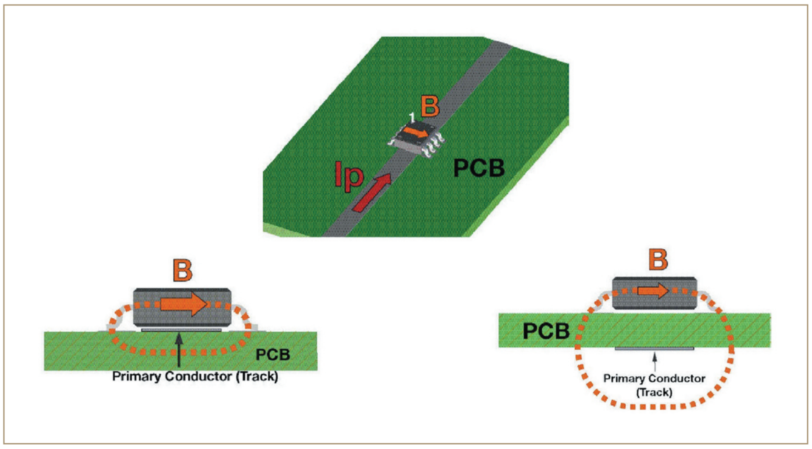


Figure 4: Principle of Minisens to measure current in a PCB track

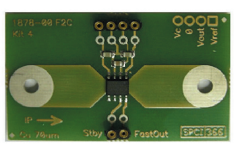
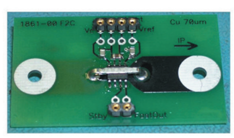
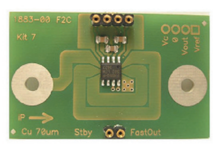
Low isolation 0.4 mm clearance & creepage distances	 1 turn (kit n° 4)	 With jumper (kit n° 6)	 Multi turns (kit n° 7)
I_{PN} [A] @ Tamb = 85 °C (T_{PCB} max 115 °C)	16	10	5
I_{PM} [A] @ Vout = 2 [V]	30	10	11
Sensitivity [mV/A] @ 600 [mV/mT]	67.2	206.2	186.1

Figure 5: High isolation evaluation kits and their specifications