# AUTOMOTIVE CURRENT TRANSDUCER OPEN LOOP TECHNOLOGY
# HC5FW 100-S/SP1



## Introduction

The HC5FW family is for the electronic measurement of DC, AC or pulsed currents in high power and low voltage automotive applications with galvanic separation between the primary circuit (high power) and the secondary circuit (electronic circuit).

The HC5FW family gives you the choice of having different current measuring ranges in the same housing.

## Features

- Open Loop transducer using the Hall effect
- Low voltage application
- Unipolar +5 V DC power supply
- Primary current measuring range up to ±100 A
- Maximum RMS primary current limited by the busbar, the magnetic core or the ASIC temperature T° < +150 °C
- Operating temperature range: −40 °C < T° < +125 °C
- Output voltage: full ratiometric (sensitivity and offset)
- High speed transducer.

## Special feature

- Cover without sleeve (reduced insulation).

## Advantages

- Good accuracy
- Good linearity
- Low thermal offset drift
- Low thermal sensitivity drift.

## Automotive applications

- Electrical Power Steering
- Starter Generators
- Converters.

## Principle of HC5FW family

The open loop transducers uses a Hall effect integrated circuit. The magnetic flux density *B*, contributing to the rise of the Hall voltage, is generated by the primary current $I_P$ to be measured. The current to be measured $I_P$ is supplied by a current source i.e. battery or generator (Figure 1).
Within the linear region of the hysteresis cycle, *B* is proportional to:

$$B\ (I_P) = \text{constant (a)} \times I_P$$

The hall voltage is thus expressed by:

$$V_H = (\text{Hall coefficient} / d) \times I \times \text{constant (a)} \times I_P$$

With d = thickness of the hall plates

$I$ = current accross the Hall plates

Except for $I_P$, all terms of this equation are constant. Therefore:

$$V_H = \text{constant (b)} \times I_P$$

The measurement signal $V_H$ amplified to supply the user output voltage or current.

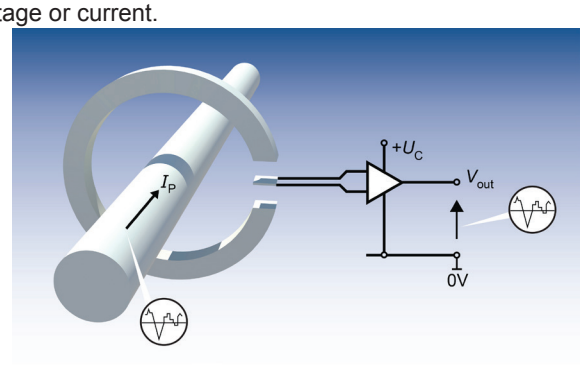
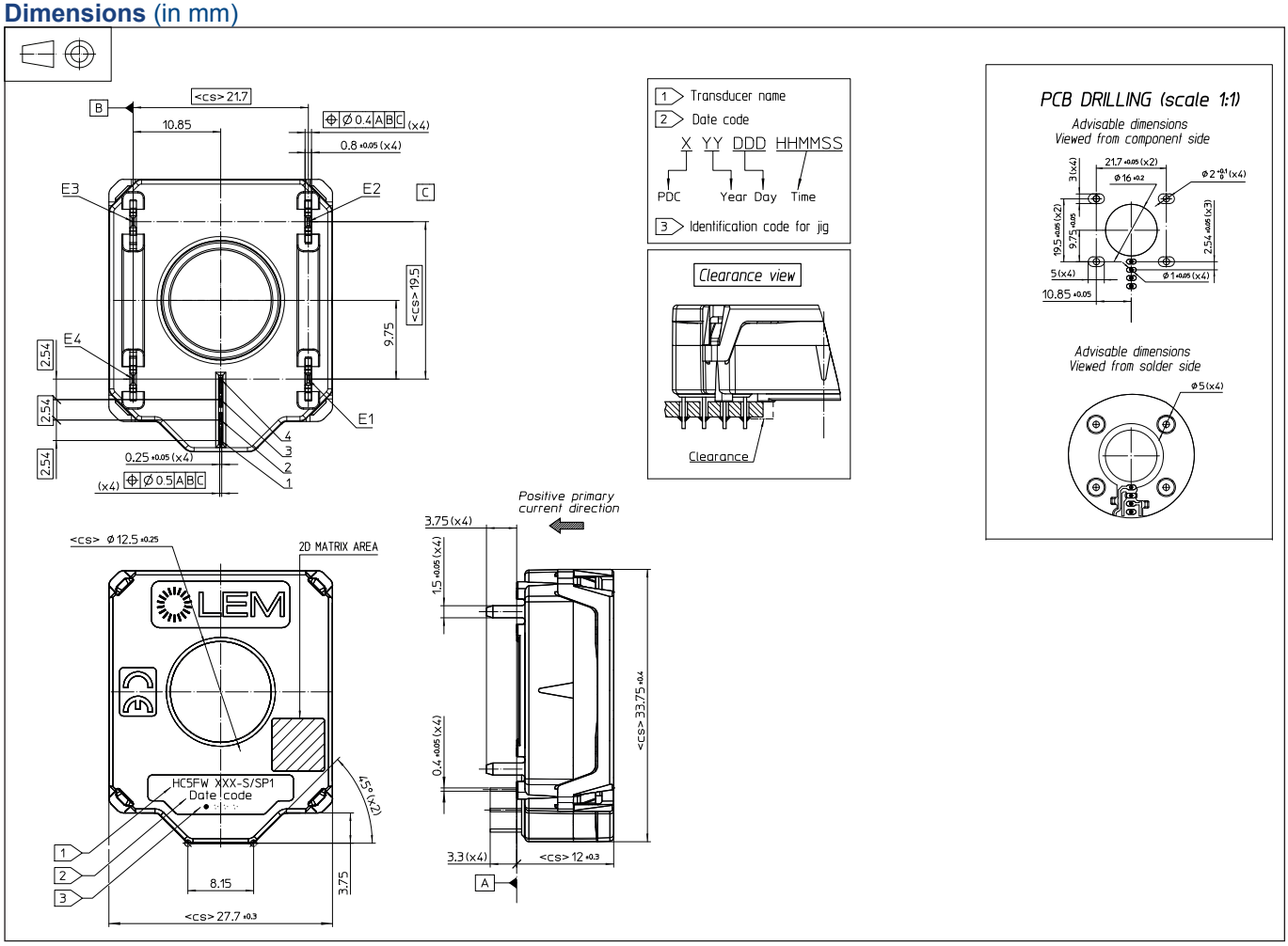



Fig. 1: Principle of the open loop transducer

## Dimensions (in mm)




## Mechanical characteristics

- Plastic case PA 66 GF 25
- Magnetic core FeSi alloy
- Mass 27.5 g
- Electrical terminal coating Tin plated
- IP level IPx00

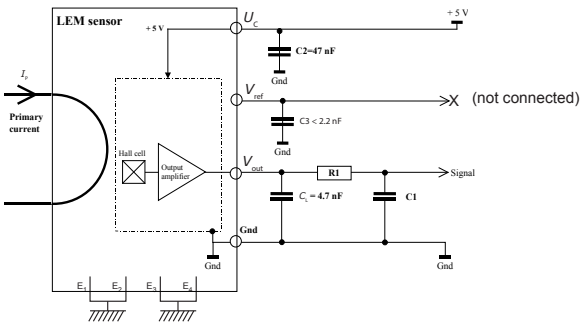
## Mounting recommendation

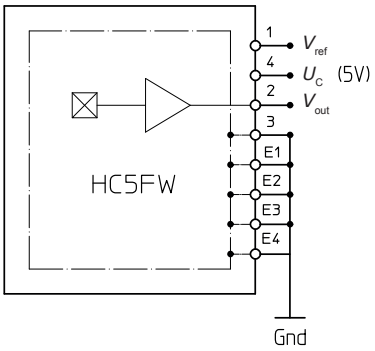
- Connector type None
- Assembly torque max None
- Soldering profile See page 7

## Remarks

- $V_{out}$ > $V_o$ when $I_P$ flows in the positive direction (see arrow on drawing)
- R1, C1: low pass filter (optional).

## Electronic schematic





LEM reserves the right to carry out modifications on its transducers, in order to improve them, without prior notice

## Absolute ratings (not operating)

| Parameter | Symbol | Unit | Specification | | | Conditions |
|---|---|---|---|---|---|---|
| | | | Min | Typical | Max | |
| Maximum supply voltage | $U_C$ | V | | | 8 | not operating |
| | | | | | 6.5 | Exceeding this voltage may temporary reconfigure the circuit until the next power-on |
| Maximum primary current peak | $\hat{I}_P$ | A | | | 3) | |
| Ambient storage temperature | $T_S$ | °C | −40 | | 125 | |
| Electrostatic discharge voltage | $U_{ESD}$ | kV | | | 2 | JESD22-A114-B class 2 |
| Maximum admissible vibration (random) | γ | $m \cdot s^{-2}$ | | 90 | | 10 to 1000 Hz |
| Rms voltage for AC insulation test, 50 Hz, 1 min | $U_d$ | kV | | | 2.5 | 50 Hz, 1 min, IEC 60664 part1 |
| Insulation resistance | $R_{IS}$ | MΩ | 500 | | | |
| Creepage distance | $d_{Cp}$ | mm | | 3.6 | | |
| Clearance | $d_{Cl}$ | mm | | 2.7 | | |
| Comparative traking index | *CTI* | | | 550 | | |
| Maximum reverse current | $I_R$ | mA | −80 | | 80 | |

## Operating characteristics in nominal range ($I_{PN}$)

| Parameter | Symbol | Unit | Specification | | | Conditions |
|---|---|---|---|---|---|---|
| | | | Min | Typical | Max | |
| **Electrical Data** | | | | | | |
| Primary current, measuring range | $I_{PM}$ | A | −100 | | 100 | |
| Primary nominal DC or rms current | $I_{PN}$ | A | −100 | | 100 | |
| Supply voltage 1) | $U_C$ | V | 4.75 | 5.00 | 5.25 | |
| Ambient operating temperature | $T_A$ | °C | −40 | | 125 | |
| Output voltage (Analog) | $V_{out}$ | V | $V_{out} = (U_C/5) \times (V_o + G \times I_P)$ | | | @ $U_C$ |
| Sensitivity | *G* | mV/A | | 20 | | @ $U_C$ = 5 V |
| Offset voltage | $V_O$ | V | | 2.5 | | @ $U_C$= 5 V |
| Current consumption | $I_C$ | mA | | 19 | 25 | @ $U_C$ = 5 V, −40 °C < $T_A$ < 125 °C |
| Load resistance | $R_L$ | KΩ | 10 | | | |
| Capacitive loading | $C_L$ | nF | | 4.7 | 6.8 | |
| Output internal resistance | $R_{out}$ | Ω | | | 10 | DC to 1 KHz |
| **Performance Data** 1) | | | | | | |
| Ratiometricity error | $\varepsilon_r$ | % | | 0.5 | | |
| Sensitivity error | $\varepsilon_G$ | % | | ±0.6 | | @ $T_A$ = 25 °C |
| Electrical offset voltage | $V_{OE}$ | mV | | ±3.5 | | @ $T_A$ = 25 °C, @ $U_C$ = 5 V |
| Magnetic offset voltage | $V_{OM}$ | mV | | ±2 | | @ $T_A$ = 25 °C, @ $U_C$ = 5 V, after ± $I_P$ |
| Global accuracy @ 0 A | $X_G$ | mV | −13 | | 13 | @ $T_A$ = 25 °C, @ $U_C$ = 5 V, Hysteresis included |
| Average temperature coefficient of $V_{OE}$ | $TCV_{OE\,AV}$ | mV/°C | −0.08 | | 0.08 | @ −40 °C < T° < 125 °C |
| Average temperature coefficient of *G* | $TCG_{AV}$ | %/°C | −0.03 | | 0.03 | @ −40 °C < T° < 125 °C |
| Linearity error | $\varepsilon_L$ | % $I_P$ | −1 | | 1 | Of full range |
| Step response time to 90 % $I_{PN}$ | $t_r$ | µs | | 2 | 6 | d*i*/d*t* = 100 A/µs |
| Frequency bandwidth 2) | *BW* | kHz | 40 | | | @ −3 dB |
| Phase shift | Δφ | °C | −4 | | 0 | @ DC to 1 kHz |
| Minimum output voltage | $V_{SZ}$ | V | | | 0.2 | @ $U_C$ = 5 V |
| Maximum output voltage | | V | 4.8 | | | @ $U_C$ = 5 V |
| Output voltage noise peak-peak | $V_{no\,pp}$ | mV | | | 15 | DC to 1 MHz |

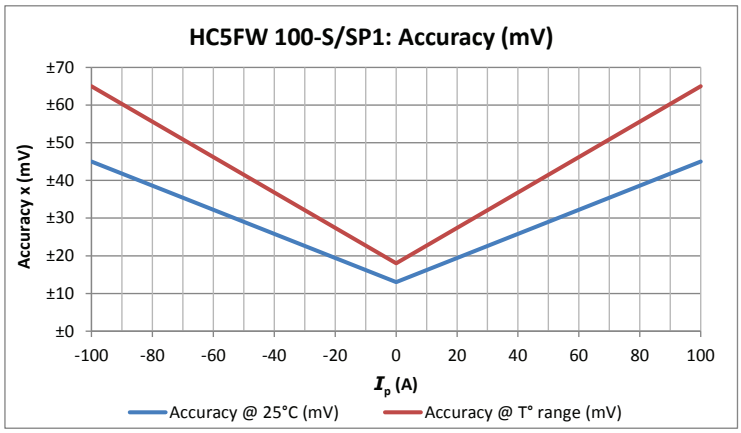
Notes: 1) The output voltage $V_{out}$ is fully ratiometric. The offset and sensitivity are dependent on the supply voltage $U_C$ relative to the following formula:

$$I_P = \left(\frac{5}{U_C} \times V_{out} - V_O\right) \times \frac{1}{G} \text{ with G in (V/A)}$$

2) Small signal only to avoid excessive heating of the busbar, core and heating. Measurement with C3 = 1 nF.

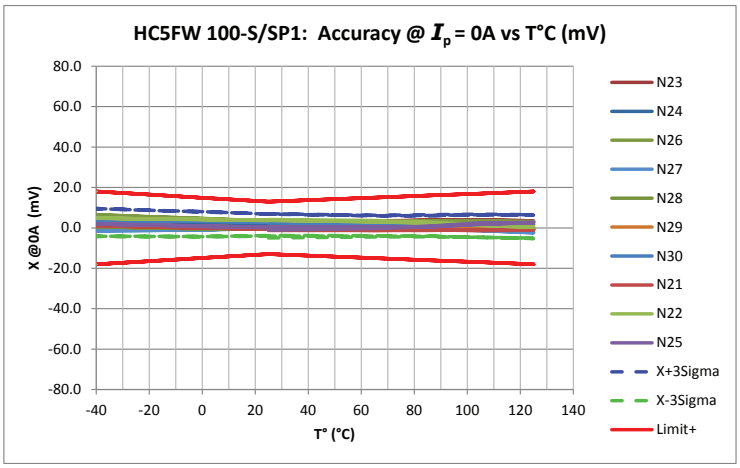

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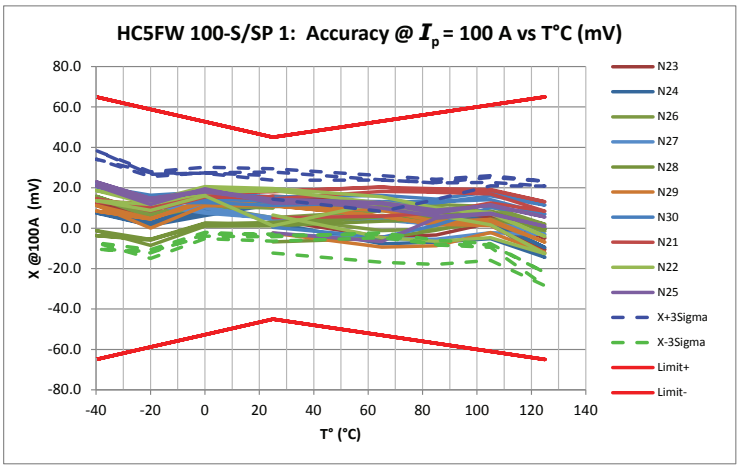
## Global Absolute Error (mV)




| $I_p$ (A) | Accuracy @ 25 °C (mV) | Accuracy @ T° Rrange (mV) |
|---|---|---|
| −100 | ±45 | ±65 |
| 0 | ±13 | ±18 |
| 100 | ±45 | ±65 |

Accuracy error specified at ±3 sigma.



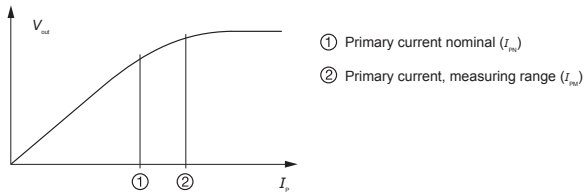




Curves in red line represent the tolerance
Curves in dotted line represent average ±3 sigma.


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## PERFORMANCES PARAMETERS DEFINITIONS

### Primary current definition:




### Definition of typical, minimum and maximum values:

Minimum and maximum values for specified limiting and safety conditions have to be understood as such as values shown in “typical” graphs. On the other hand, measured values are part of a statistical distribution that can be specified by an interval with upper and lower limits and a probability for measured values to lie within this interval. Unless otherwise stated (e.g. “100 % tested”), the LEM definition for such intervals designated with “min” and “max” is that the probability for values of samples to lie in this interval is 99.73 %. For a normal (Gaussian) distribution, this corresponds to an interval between −3 sigma and +3 sigma. If “typical” values are not obviously mean or average values, those values are defined to delimit intervals with a probability of 68.27 %, corresponding to an interval between −sigma and +sigma for a normal distribution. Typical, minimum and maximum values are determined during the initial characterization of a product.

### Output noise voltage:

The output voltage noise is the result of the noise floor of the Hall elements and the linear amplifier.

### Magnetic offset:

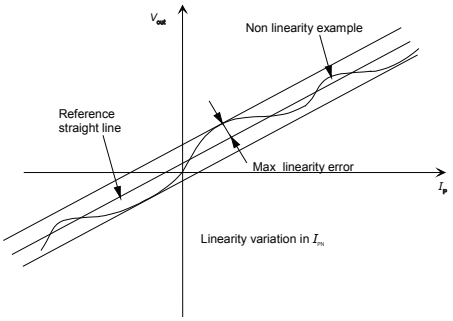
The magnetic offset is the consequence of an over-current on the primary side. It’s defined after an excursion of $I_{PN}$.

### Linearity:

The maximum positive or negative discrepancy with a reference straight line $V_{out} = f(I_P)$.
Unit: linearity (%) expressed with full scale of $I_{PN}$.

### Response time (delay time) $t_r$:

The time between the primary current signal ($I_{PN}$) and the output signal reach at 90 % of its final value.

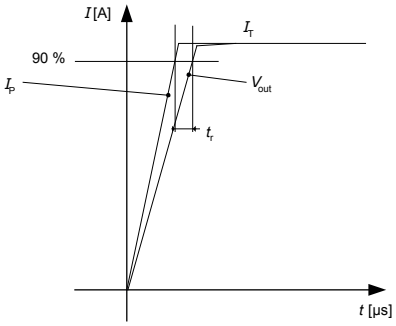



### Sensitivity:

The transducer’s sensitivity $G$ is the slope of the straight line $V_{out} = f(I_P)$, it must establish the relation:

$$V_{out}(I_P) = U_C/5\ (G \times I_P + V_o)$$

### Offset with temperature:




The error of the offset in the operating temperature is the variation of the offset in the temperature considered with the initial offset at 25 °C.
The offset variation $I_{OT}$ is a maximum variation the offset in the temperature range:

$$I_{OT} = I_{OE}\ \text{max} - I_{OE}\ \text{min}$$

The offset drift $TCI_{OEAV}$ is the $I_{OT}$ value divided by the temperature range.

### Sensitivity with temperature:

The error of the sensitivity in the operating temperature is the relative variation of sensitivity with the temperature considered with the initial offset at 25 °C.
The sensitivity variation $G_T$ is the maximum variation (in ppm or %) of the sensitivity in the temperature range:
$G_T$ = (Sensitivity max - Sensitivity min) / Sensitivity at 25 °C.
The sensitivity drift $TCG_{AV}$ is the $G_T$ value divided by the temperature range. Deeper and detailed info available is our LEM technical sales offices (www.lem.com).

### Offset voltage @ $I_P$ = 0 A:

The offset voltage is the output voltage when the primary current is zero. The ideal value of $V_O$ is $U_C/2$. So, the difference of $V_O$ -$U_C/2$ is called the total offset voltage error. This offset error can be attributed to the electrical offset (due to the resolution of the ASIC quiescent voltage trimming), the magnetic offset, the thermal drift and the thermal hysteresis. Deeper and detailed info available is our LEM technical sales offices (www.lem.com).

## Environmental test specifications:

Refer to LEM GROUP test plan laboratory CO.11.11.515.0 with “Tracking_Test Plan_Auto” sheet.

| Name | Standard |
|---|---|
| **THERMAL FATIGUE** | |
| Ageing 85 °C / 85 % *HR* / 1000 h<br>Thermal cycle test −40 °C / 125 °C / 1000 h<br>Thermal shocks −40 °C / 125 °C / 1000 h<br>High temperature storage at 125 °C / 1000 h<br>Low temperature storage at −50 °C / 1000 h | IEC 60068-2-78 (2001)<br>IEC 60068-2-14 test Nb (01.2009)<br>IEC 60068-2-14 test Na (01.2009)<br>IEC 60068-2-2 (07.2007)<br>IEC 60068-2-1 (03.2007) |
| **MECHANICAL FATIGUE** | |
| Shocks test (50 m·s$^2$ x 10 x 3 axis)<br>Vibration test (random 10 - 2000 Hz / 9.723 g) | IEC 60068-2-27 test Ea (2008) |
| **ELECTRICAL TESTS** | |
| Phase delay<br>Output noise<br>d*i*/d*t* (100 A/µs)<br>d*v*/d*t* (2 kVA/µs to 2 kV)<br>Withstand voltage (2500 V rms - 50 Hz / 1 min)<br>Insulation resistance (500 Vdc / 1 min) | --<br>98.20.00.575.0<br>98.20.00.545.0<br>98.20.00.545.0<br>ISO 16750-2 (2012) |
| **EMC TESTS** | |
| Radiated Emissions: Absorber Lined Shielded Enclosure (ALSE)<br>Radiated Immunity: Bulk Current Injection (BCI)<br>Radiated Immunity: Anechoic chamber<br>Resistance to Electrostatic Discharge Voltage | IEC CISPR25<br>ISO 11452-1 & -4<br>ISO 11452-1 & -2<br>ISO 10605 (2001) |

### Moisture sensitivity level (MSL) information:

- MSL level 1

### PCB recommendations:

- Thickness 1.6 mm
- Plated-through holes

Mass/Body pin (E1 to E4. See drawing on page 2): 2 mm diameter
Asic pin (1,2,3,4. See drawing on page 2): 1 mm diameter.

### Soldering recommendations:

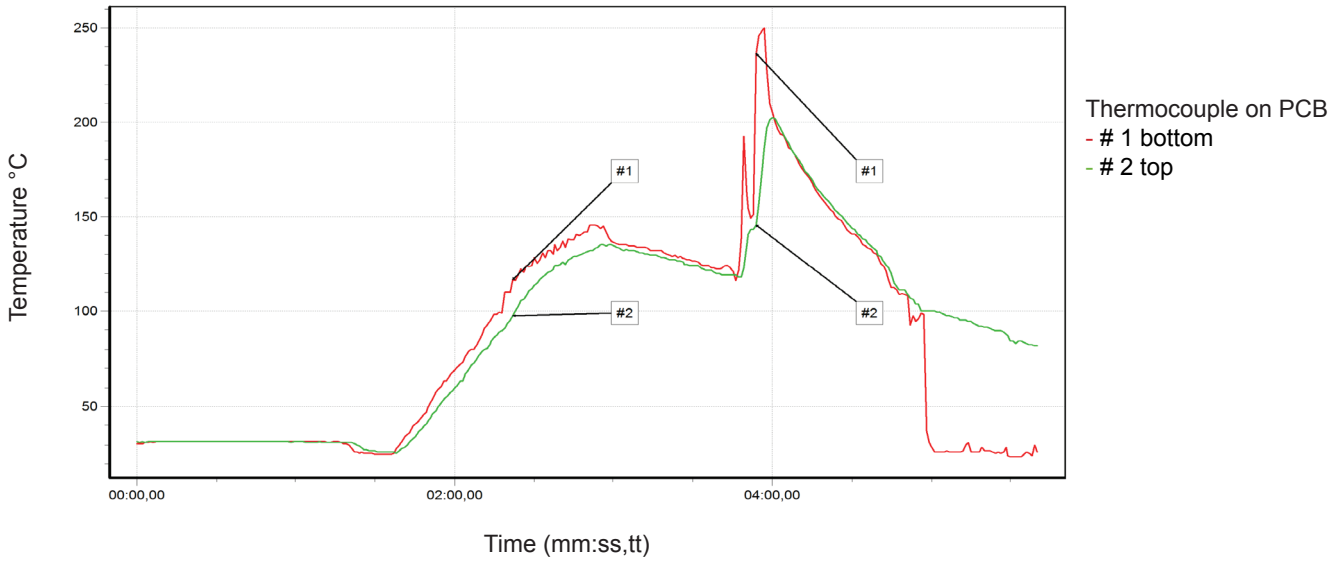
**1. Hand soldering**

Mass/Body pin (E1 to E4. See drawing on page 2): 200 W / 370 °C iron temperature / 7 mm flat tip (Weller W200)
Asic pin (1, 2, 3, 4. See drawing on page 2): 80 W / 410 °C iron temperature / 0.8 mm round tip (Metcal STTC125).

**2. Wave soldering**

LEM recommends to use the following equipment/parameters for the soldering of the HC5FW family in order to be compliant with the IPC A-610 (less than 75 % land coverage):

- Machine VITRONICS SOLTEC 6622 in combi wave mode
- Flux SLS 65
- Sn96 lead free solder (SAC 305)
- Temperature profile as below.




**3 - SMD soldering by pin in paste STH (SMD through hole)**

- Must be validated by user.


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