User guide

Current Transducer HMSR-SMS series

Ref: HMSR 6-SMS, HMSR 8-SMS, HMSR 10-SMS, HMSR 15-SMS, HMSR 20-SMS, HMSR 30-SMS

This document is a user guide for using HMSR series.
This document consists of following.

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1. General features

HMSR is an open loop hall effect transducer having a miniature ferrite and a proprietary ASIC (Figure 1) to allow direct current measurement and consistent insulation performance.

The ferrite used in the product is also a key factor in achieving a high-frequency bandwidth of 300 kHz (-3 dB) and makes it possible to achieve good rejection against external fields.

The product provides an accuracy across a range of temperatures, from -40 °C to +125 °C with a typical value of 1 % 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.

General features are given as follows:

- I_{PN} = 6, 8, 10, 15, 20 or 30 A RMS as primary nominal current
- The measurement range (full scale) is given as I_{PN} x 2.5 A pk
- The operating temperature range is given by -40 °C to +125 °C
- 8 mm creepage and clearance distances with CTI 600
- The reinforced insulation by IEC 60950-1 (4.95 kV RMS as Insulation test voltage)
- It withstands overload current bursts up to 20 kA (8-20 µs) when installed on a properly designed Printed Circuit Board (PCB)
- 2 µs delay time
- SOIC16-like packaging footprint having 6 mm height for Surface Mounted Devices (SMD) assembly

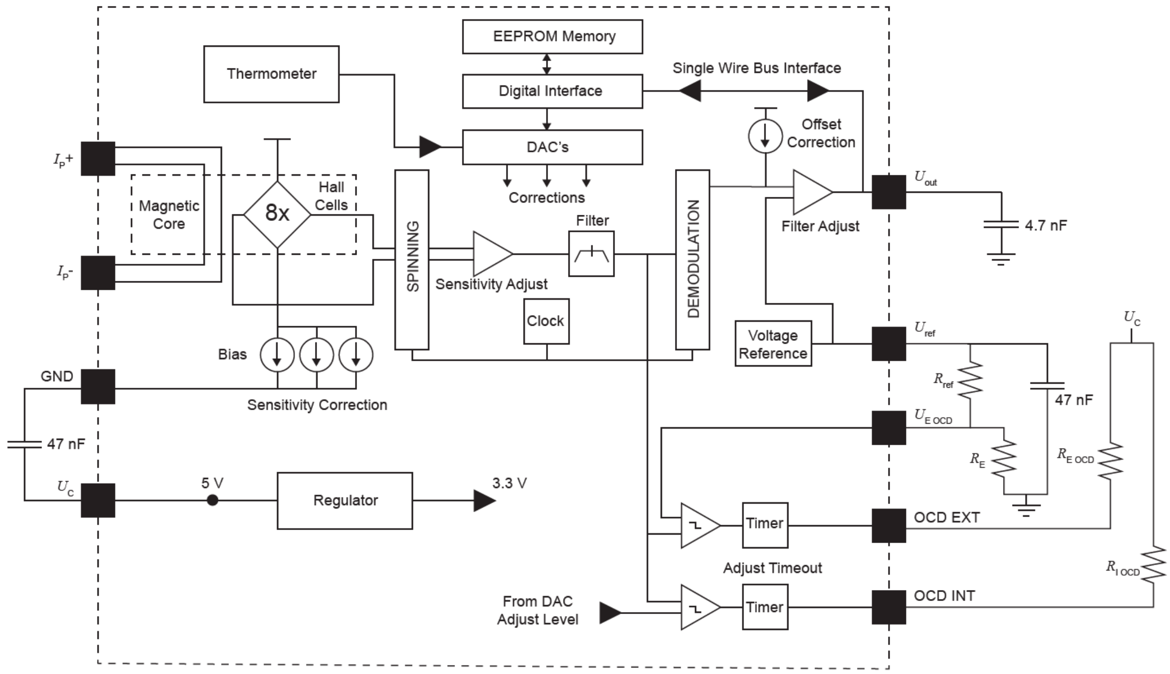


Figure 1 ASIC block diagram

Table 1 shows the product line up.

Product	U_c (V)	Range (A)	Error (mV/A)	U_{out} type	Package
HMSR 6-SMS	5	±15	133.33	Fixed U_{ref}	HMSR
HMSR 8-SMS	5	±20	100	Fixed U_{ref}	HMSR
HMSR 10-SMS	5	±25	80	Fixed U_{ref}	HMSR
HMSR 15-SMS	5	±37.5	53.33	Fixed U_{ref}	HMSR
HMSR 20-SMS	5	±50	40	Fixed U_{ref}	HMSR
HMSR 30-SMS	5	±75	26.67	Fixed U_{ref}	HMSR

Table 1 HMSR xx-SMS series

2. Electrical characteristics

2.1. Temperature Drift

Within an overall temperature range from -40 °C to +125 °C, the typical measured current accuracy of an HMSR 20-SMS is shown in Figure 2 (a).
The graph in Figure 2 (b) shows the linearity on the same temperature range.

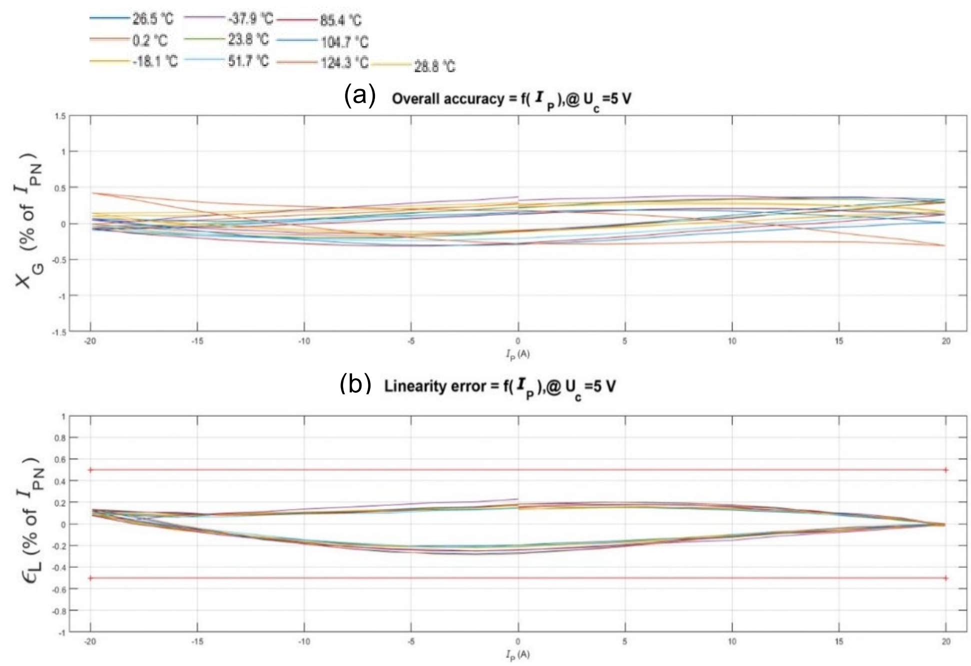


Figure 2 Temperature drift of Total error and Linearity

2.2. d*i*/d*t*

The delay time to 10 % and the delay time to 90 % are respectively below 1.5 µs and 2 µs. The typical measurement waveform is shown by Figure 3.

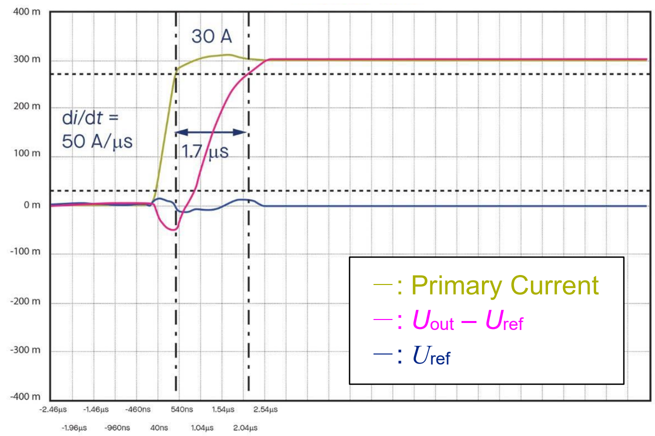


Figure 3 Step delay waveform

2.3. d*v*/d*t*

The following graphs (Figure 4) show the disturbance created by applying a ±1 kV at 20 kV/µs d*v*/d*t* step between primary and secondary side of the sensor.
The error generated is 3 % of full scale with a recovery time of 3.8 µs.

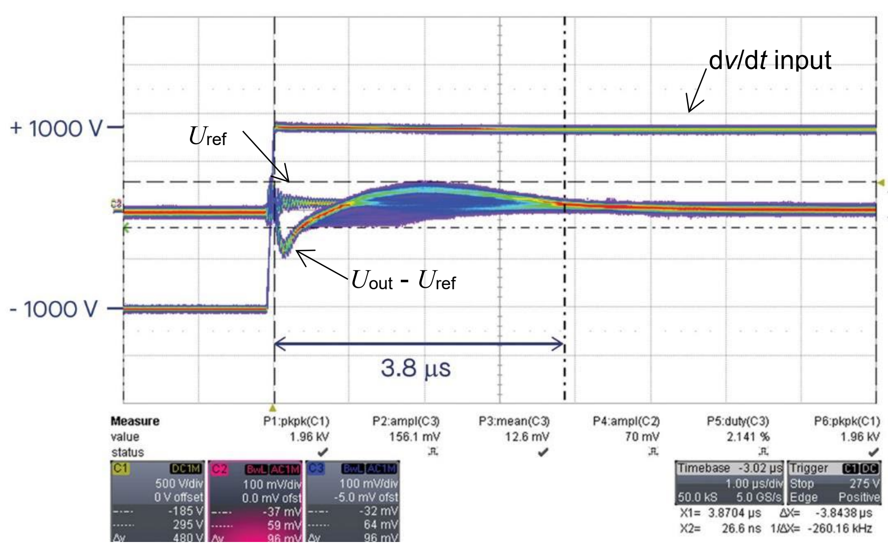


Figure 4 d*v*/d*t* waveform

2.4. Electrical and thermal resistance

The electrical resistance of the primary conductor is 0.75 mΩ typical at 25 °C.
It has the same temperature coefficient as copper, α = 0.393 %/K.
The thermal resistance, junction to case is 18 K/W typical [1)].
Figure 5 (a) show the position of the temperature sensor used for junction case measurement.

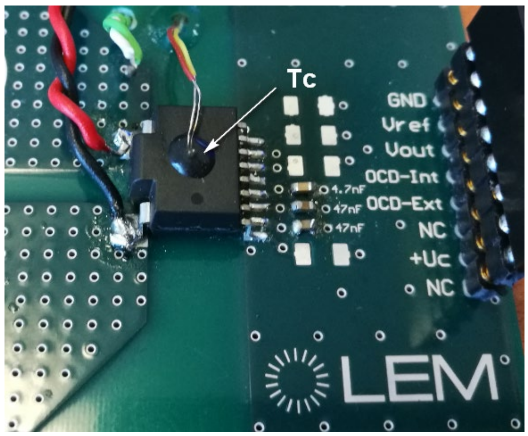


Figure 5 Temperature measurement positions (a)

Note: [1)] Done with LEM evaluation board PCB2325.

Figure 5 (b) show the nominal (thermal) current versus ambient temperature.

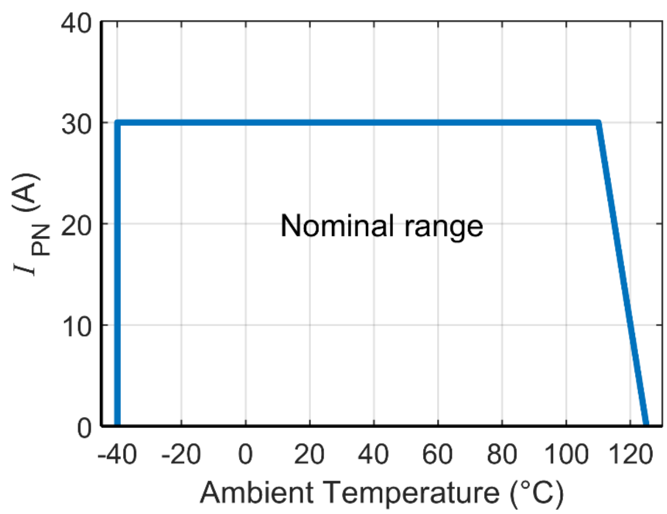


Figure 5 Nominal range versus Ambient Temperature (b)

3. Guidelines of Board Design

3.1. Analog output

Two examples of external circuit with or without using reference voltage are presented hereunder.
Whenever possible LEM recommends using U_{ref} in combination with U_{out} (3.1.2).

3.1.1. Measurement without using reference voltage Uref.

Recommended circuit without using reference voltage U_{ref} is given in Figure 6.
Bypass capacitor should be placed close to U_c, U_{out} and U_{ref} pins. U_{ref} is set to be "OPEN".
Other non-connected pins are set to be either "OPEN" or "GND connection" depending on the application.
For more specific recommendations, please call your LEM sales contact.
The traces from U_c and U_{out} pins are recommended to be wide, short and surrounded by the ground plane to reduce the influence of switching noises from the power lines.

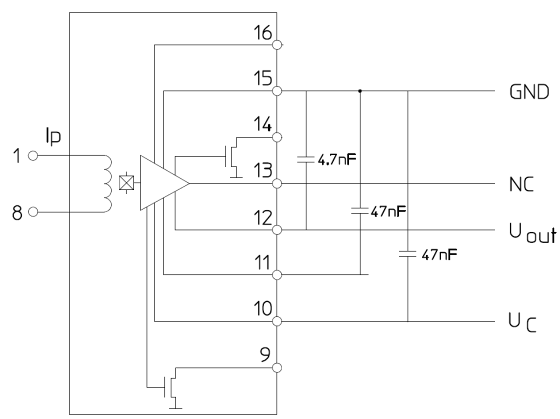


Figure 6 Circuit recommendation (a)

3.1.2. Measurement using reference voltage U_{ref}

Recommended circuit using reference voltage U_{ref} is given in Figure 7.
Bypass capacitor should be placed close to U_c, U_{out} and U_{ref} pins.
The traces from U_c and U_{out} pins are recommended to be wide, short and surrounded by the ground plane to reduce the influence of switching noises from the power lines.

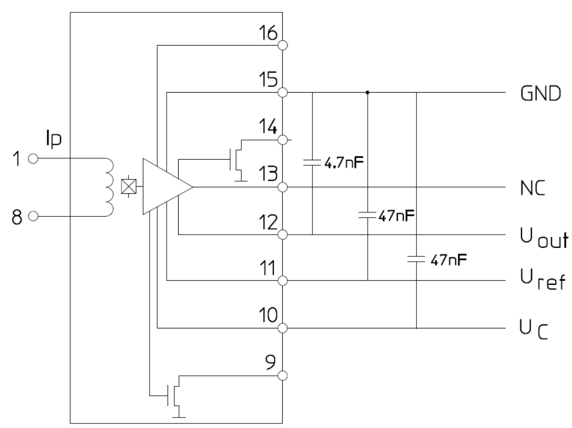


Figure 7 Circuit recommendation (b)

3.2. Over Current Detection, OCD

This function provides an over-current event signal by OCD_INT and OCD_EXT pins.

3.2.1. The internal Over Current Detection, OCD_INT

The internal threshold level of OCD_INT is set to 2.75 x $I_{P\,N}$ with +/-10 % accuracy of the HMSR. Although, the threshold level of OCD_INT, 2.75 x $I_{P\,N}$, is above the measuring range of HMSR, the over current can be still detected.
The OCD_INT signal is separated from the main current measurement signal of U_{out}.
The OCD_INT signal provides the same behavior as OCD_EXT with overcurrent duration time of 1.7 µs instead of 10 µs.

3.2.2. The external Over Current Detection, OCD_EXT

An external overcurrent detection, OCD_EXT, can be set with resistors divider on $U_{\text{E OCD}}$ pin (16). Refer to following formulas (2) and (3) and Figure 8 (a) for external OCD threshold at $U_{\text{ref}} = 2.5$V, setting with $0.3 \le U_{\text{E OCD}} \le U_{\text{ref}}$.

$$I_{\text{E OCD}} = \frac{1000 \times (U_{ref} - U_{\text{E OCD}})}{G_{th}} \quad (2)$$

$$U_{\text{E OCD}} = \frac{R_E}{R_E + R_{ref}} \times U_{ref} \quad (3)$$

When the duration of the overcurrent is detected for more than 10 µs, the OCD_EXT signal turns on, switching from a high (U_{C}) to a low level (0 V). The signal holds while primary current is higher than the threshold level as shown in Figure 8 (b).

If the overcurrent duration is less than 20 µs, a 10 µs overcurrent signal hold time is maintained as shown in Figure 8 (c).

If the duration of the overcurrent is below 10 µs, the OCD_EXT does not turn on Figure 8 (d).

The detection accuracy is +/-6 %.

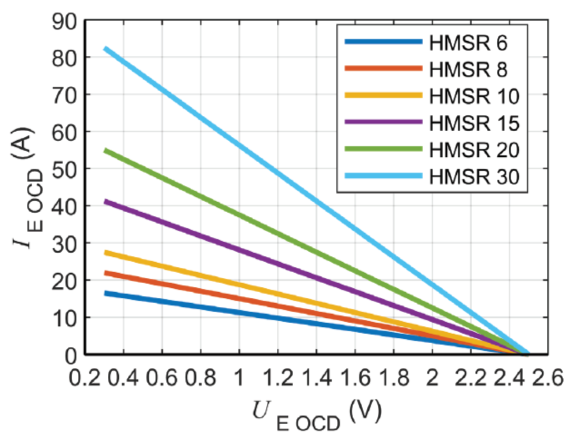


Figure 8 OCD_EXT threshold (a)

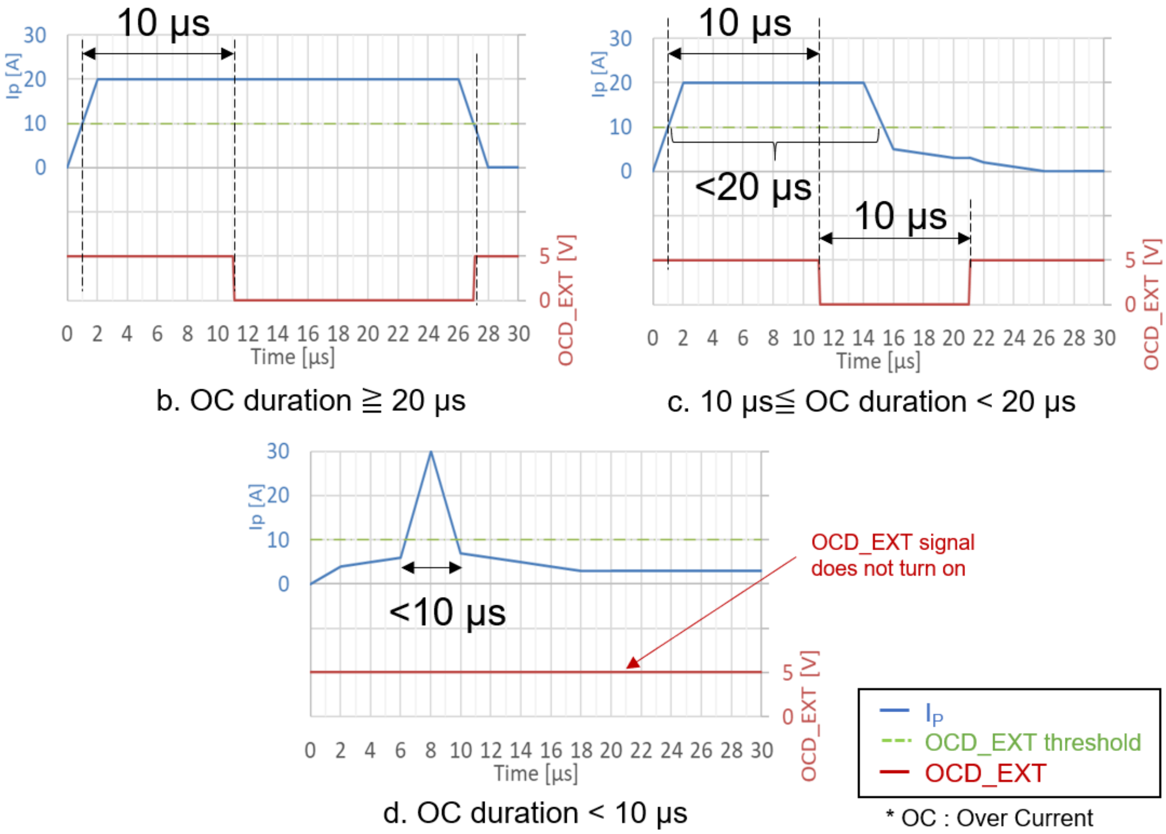


Figure 8 Typical waveform of overcurrent detection OCD_EXT (b-c-d)

3.3. Primary current path on PCB

The primary conductor paths should be at the same time wide to conduct maximum current and as short as possible between source and load in order to minimize the resistance of primary conductor.

Higher conductor resistance will cause Joule heating of the overall primary circuit of the current transducer.

3.3.1. Footprint

Recommended soldering pad layout is given in Figure 9.

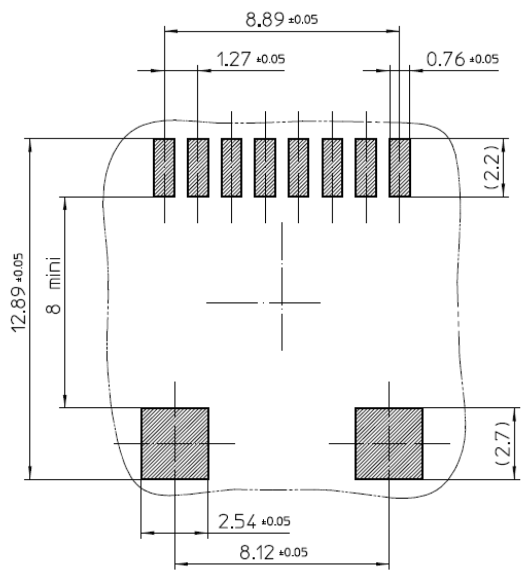
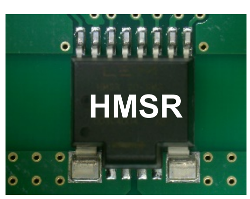


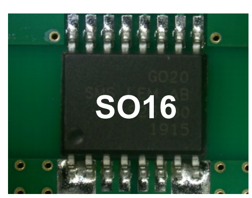
Figure 9 Recommended soldering pad layout

Dual landing PCB layout is possible with satisfactory solderability for both HMSR and SOIC 16 lead equivalent.

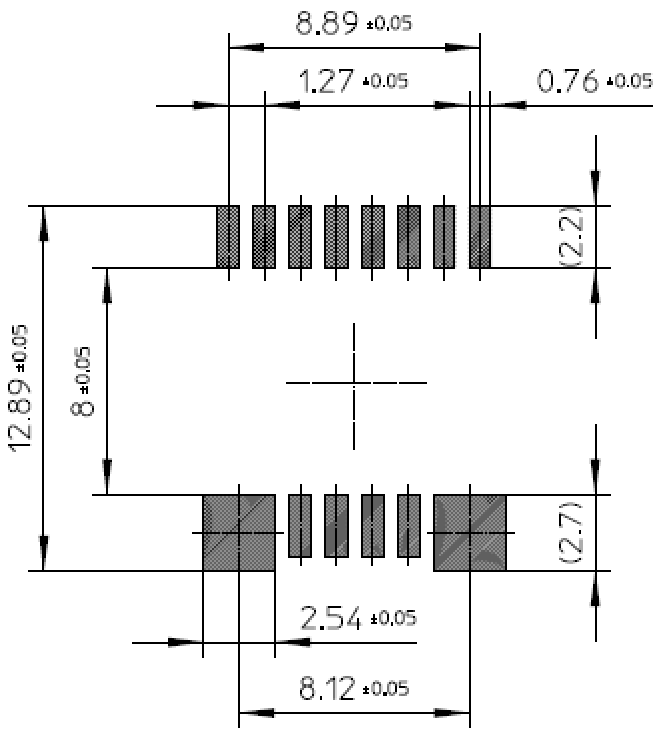
LEM testing of HMSR and SOIC 16 on a LEM designed PCB passed all IPC-7351 Density Level B requirements for PCB's with clearance distance of 8 mm.

For more information, PCB drawings, and a detailed report, please contact your LEM sales person.





Alternative dual landing soldering pad layout is given in Figure 9a.



3.3.2. Pin configuration

Pin configuration is given in Figure 10 and Table 2.

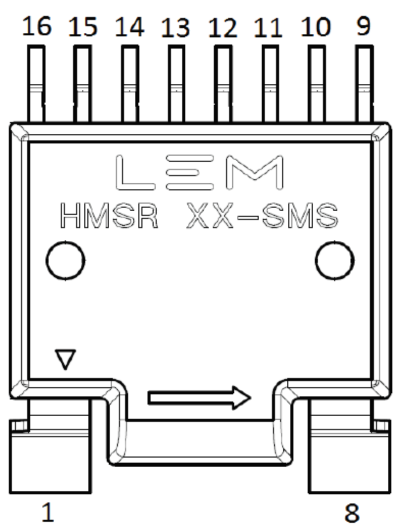


Figure 10 Pin configuration

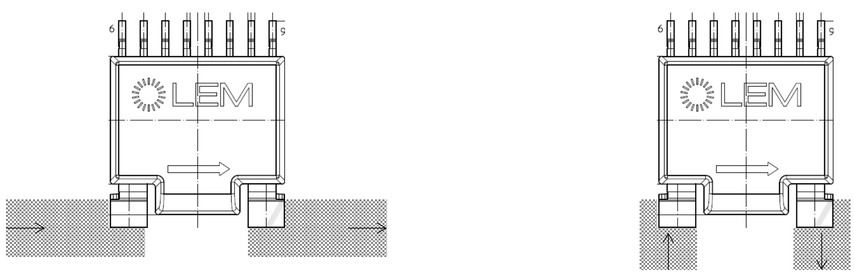
Table 2 Pin connection of HMSR xx-SMS

Pins number	Name	Description
1	I_P+	Input of the primary current
8	I_P−	Output of the primary current
9	OCD INT	Internal OCD
10	U_C	Supply voltage
11	U_{ref}	Reference voltage
12	U_{out}	Output voltage
13	NC	No internal connection
14	OCD EXT	External OCD terminal
15	GND	Ground terminal
16	$U_{E\ OCD}$	External OCD threshold voltage terminal

Note: when the OCD function is not used, the OCD_INT (pin 9), $U_{E\ OCD}$ (pin 16), and OCD_EXT (pin 14) pins are either "OPEN" or "GND connection" is OK.

3.3.3. Primary current path

Recommended primary current paths are presented below.
The straight current carrying path from right to left is shown in the Figure 11 (a). If this current path cannot be realized due to board layout constraints, the path having an opposite direction of the secondary pins, as shown in Figure 11 (b) is recommended.
The layout shown in Figure 12 in not recommended as this may degrade the system isolation characteristics.
Likewise, it is not recommended to have the current-carrying paths underneath the current transducer.
Besides potential isolation issues, the output could be influenced magnetic fields generated by primary current.



(a) Straight path (b) Away from secondary side

Figure 11 Example of recommended primary current path designs

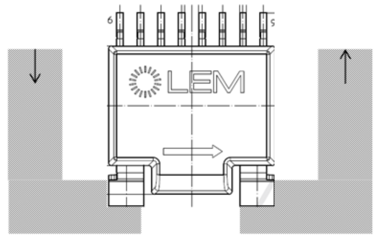


Figure 12 Example of a not recommended primary current path design

3.4. Insulation design

The internal distance between primary and secondary sides of the transducer helps to insulate the primary bar from the rest of the IC.
The insulation level is 100 % test to 4.95 kV RMS, in accordance with IEC 60950-1: 2005.
The footprint of the HMSR design allows 8 mm of creepage and clearance distances between the opposed primary and secondary landing pads.

3.5. Thermal design and overcurrent capability

The HMSR is designed to can carry 30 A RMS continuous current.
The transducer can also withstand surge currents up to 20 kA, while maintaining both functionality and insulation.
This surge current capability simulates the equivalent of a lightning strike and the HMSR mounted on a LEM designed test PCB has been tested to this level in accordance with the IEC 600060-1 standard 8/20 μs surge test profile, Figure 13.

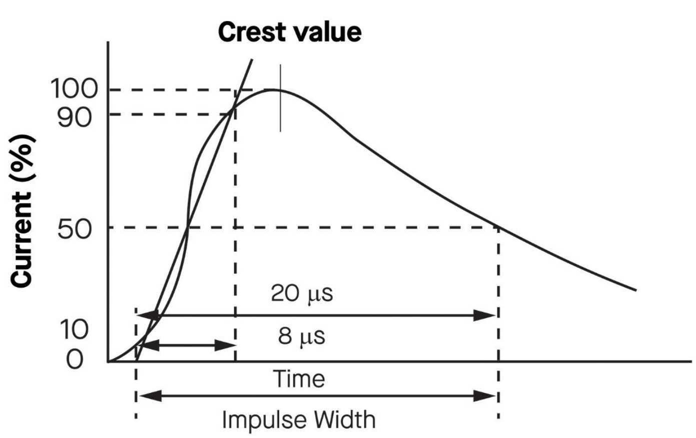


Figure 13 Typical overcurrent surge profile in solar applications

3.6. External magnetic field guideline

The measurement values of HMSR output characteristics under a uniform external magnetic field are given in Figure 14.
The output perturbation on the XYZ axes given in Figure 14 is measured data.

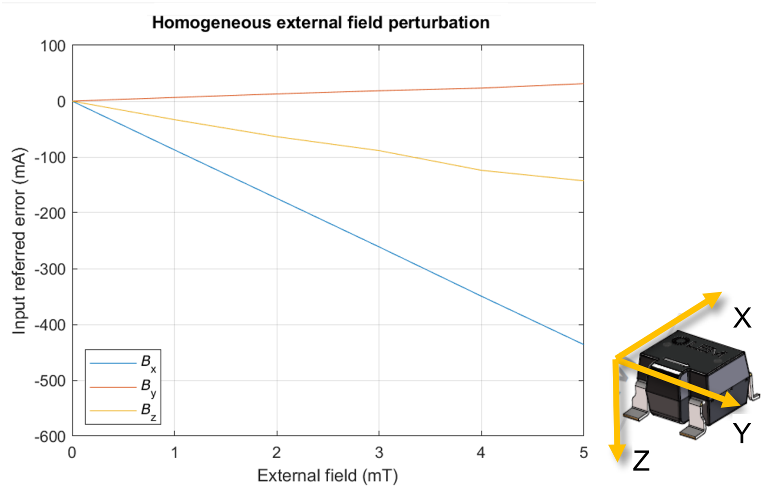


Figure 14 Perturbation of the output by external magnetic field

4. Others

4.1. Supply Voltage

HMSR uses the FIX gain mode. For power supply voltage U_c = 5 V, HMSR has been designed to resist external perturbation of the output signal, see Figure 15.

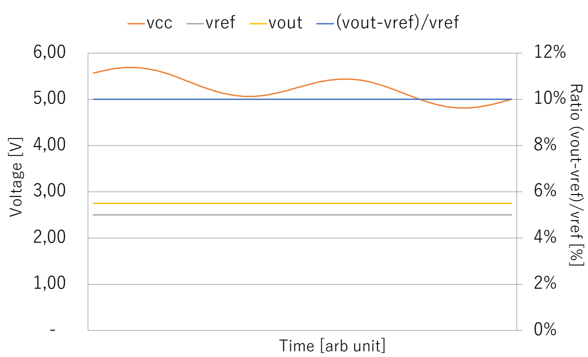


Figure 15 U_c and output voltages on fixed-sensitivity output transducer

4.2. Soldering

HMSR is compliant with Pb free soldering profile of JEDEC J-STD-020 standard.
In considering the HMSR package (thickness > 2.5 mm and 350 < volume < 2000 mm^3), the peak profile temperature T_P shall be 245 °C.
The profile is given in Figure 16.

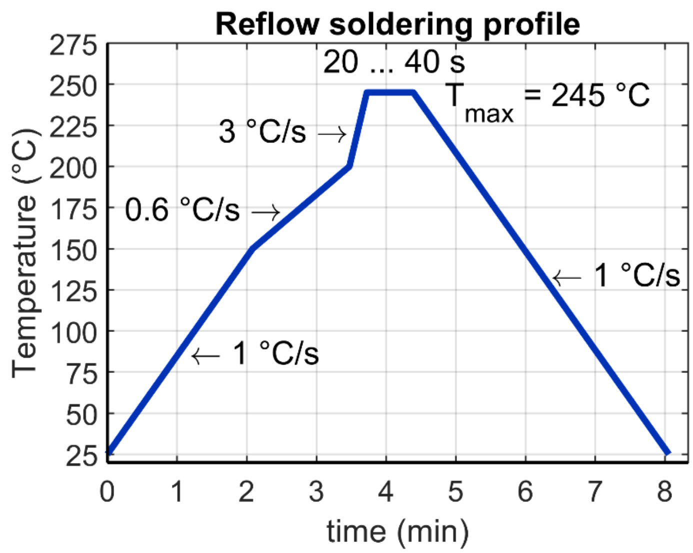


Figure 16 Reflow soldering profile

Having a ferrite in the product, it is not recommended to solder using an IR (infrared) reflow system.
The HMSR is best soldered either in a multizone reflow system (7 zones minimum) or a vapor phase process where the ramp temperatures can be very accurately controlled.
When soldering the HMSR it is best to apply a slow ramp up and down especially through the 150 to 200 °C window while respecting the overall JEDEC process time.
Time at maximum reflow temperature TP should be minimized to what assures a satisfactory solder joint and in no case should exceed the maximum JEDEC recommendation of 30 s.
LEM does not recommend reworking HMSR solder rejects.

4.3. PCB design guidelines

In order to take advantage of the HMSR surge current capabilities, care should be taken to design to also handle the surge current.
LEM recommends a 6-layer 105 µm thick copper PCB.
The board must include multiple vias especially around the primary pins in order to transfer the current and thermal energy into the lower layers of the PCB.
Care must also be given to avoid any solder voids during the mounting process as they can create weakness that will fail during a surge current occurrence.
For more specific information, please call your LEM sales contact to obtain a Gerber file with typical PCB design recommendations.

4.4. Space saving

In many applications, HMSR can be mounted directly onto a PCB like other SMD, reducing manufacturing costs and providing much needed space-saving for challenging product packaging environments.
For example, at 6 mm high, the HMSR offers space-saving in drive applications, making it ideal for placing under a heatsink placed over an Intelligent Power Modules (IPMs), shown in Figure 17.

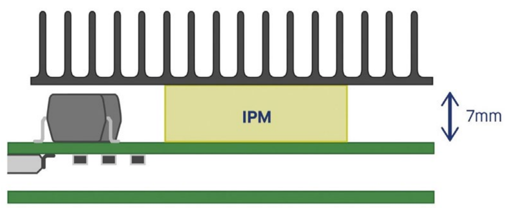


Figure 17 HMSR mounted with IPM

4.5. Handling procedures

Due to the insulative nature of the HMSR, care should be given during all operations and use of the transducer to avoid contaminating the surfaces with foreign materials that could be conductive.
Skin oil, pencil, or other conductive and or partially conductive materials can create an electrical path over the outside of the package that can lead to a short circuit and premature failure of the transducer.
Use of finger cots are recommended whenever handling the HMSR in a non-automated mode.

4.6. Standards

Following standard is certified to HMSR xx-SMS series.

- IEC 61800-5-1: 2007

  Adjustable speed electrical power drive systems – Part 5-1: Safety requirements – Electrical, thermal and energy
- IEC 62109-1: 2010

  Safety of power converters for use in photovoltaic power systems - Part 1: General requirements
- IEC 60950-1: 2005

  Information technology equipment - Safety - Part 1: General requirements
- UL1577

  Standard for Optical Isolators

Disclaimer

All information included in this document are provided only to illustrate operation and application examples of the HMSR.

How this information is used in a specific design and/or application is the customer's responsibility.

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Refer to HMSR-SMS dedicated webpage for more information.