

Integrated Current Sensor HMSR-SMS/SP3 series $I_{PN} = 20 \dots 30 \text{ A}$

Ref: HMSR 20-SMS/SP3, HMSR 30-SMS/SP3

Definition

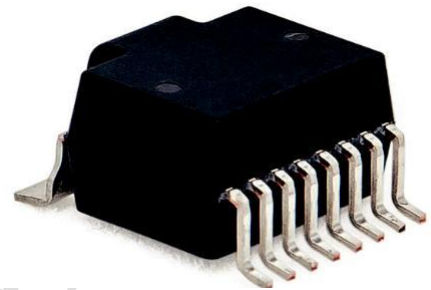
The HMSR is a new generation of high insulated Integrated Current Sensor from LEM.

This product family provides a robust, compact and very accurate solution for measuring DC and AC currents in all highly demanding, switching power applications for commercial, industrial. HMSR is a micro core based open loop sensor with a reinforced insulation and overcurrent detections (user configurable and factory set). These features make the device suitable for high voltage applications requiring high precision and strong immunity against external field.

The primary conductor (pins 1 and 8) has very low electrical resistance and dedicated pads designed to withstand against high surge currents such as lightning strikes.

HMSR is measuring the magnetic field generated by the current flowing in the copper primary path of the device. By using a micro magnetic core, HMSR is immune to the external fields, making the device well suited for power electronic applications with high levels of disturbance.

The reinforced isolation between primary (pins 1 and 8) and secondary (pins 9 to 15) offers the HMSR, a small, cost effective solution to measure high side current compared to resistive isolated solutions.



Features

- Open loop multi-range current transducer
- Voltage output
- Double overcurrent detection
- Galvanic separation between primary and secondary
- Low power consumption
- Compact design for surface mount PCB mounting
- Factory calibrated
- High bandwidth, very low loss magnetic core.

Special feature

- Single power supply +3.3 V.

Advantages

- Low profile: $h = 6 \text{ mm}$
- Small foot-print
- Low electrical resistance $0.76 \text{ m}\Omega$
- Reinforced insulation capability
- High resolution
- High immunity to external interference
- Lightning impulse current $\leq 20 \text{ kA}$.

Applications

- Small drives
- HVAC Inverters
- Appliances
- Solar Inverters.

Standards

- IEC 61800-5-1: 2007
- IEC 62109-1: 2010
- IEC 60950-1: 2005
- UL 1577: 2014 (pending).

Application Domains

- Industrial
- Automotive (pending).

Safety



Caution

If the device is used in a way that is not specified by the manufacturer, the protection provided by the device may be compromised. Always inspect the electronics unit and connecting cable before using this product and do not use it if damaged. Mounting assembly shall guarantee the maximum primary conductor temperature, fulfill clearance and creepage distance, minimize electric and magnetic coupling, and unless otherwise specified can be mounted in any orientation.



Caution, risk of electrical shock

This transducer must be used in limited-energy secondary circuits SELV according to IEC 61010-1, in electric/electronic equipment with respect to applicable standards and safety requirements in accordance with the manufacturer's operating specifications.

Use caution during installation and use of this product; certain parts of the module can carry hazardous voltages and high currents (e.g. power supply, primary conductor).

Ignoring this warning can lead to injury and or/or cause serious damage.

De-energize all circuits and hazardous live parts before installing the product.

All installations, maintenance, servicing operations and use must be carried out by trained and qualified personnel practicing applicable safety precautions.

This transducer is a build-in device, whose hazardous live parts must be inaccessible after installation.

This transducer must be mounted in a suitable end-enclosure.

Main supply must be able to be disconnected.

This transducer is a built-in device, not intended to be cleaned with any product. Nevertheless if the user must implement cleaning or washing process, validation of the cleaning program has to be done by the user in accordance with semi-conductor practices.



ESD susceptibility

The product is susceptible to be damaged from an ESD event and the personnel and work space should be grounded when handling it.

Do not dispose of this product as unsorted municipal waste. Contact a qualified recycler for disposal.

Although LEM applies utmost care to facilitate compliance of end products with applicable regulations during LEM product design, use of this part may need additional measures on the application side for compliance with regulations regarding EMC and protection against electric shock. Therefore LEM cannot be held liable for any potential hazards, damages, injuries or loss of life resulting from the use of this product.

Absolute maximum ratings

Parameter	Symbol	Unit	Value
Maximum supply voltage	$U_{C\ max}$	V	8
Maximum supply voltage (working) (-40 ... 125 °C)	$U_{C\ max}$	V	6.5
Electrostatic discharge voltage (HBM - Human Body Model)	$U_{ESD\ HBM}$	kV	2
Electrostatic discharge voltage (CDM - Charged Device Model)	$U_{ESD\ CDM}$	V	500
Maximum output current source	$I_{out\ max}$	mA	25
Maximum input current sink	$I_{in\ max}$	mA	50
Maximum junction temperature	$T_{J\ max}$	°C	150

Absolute maximum ratings apply at 25 °C unless otherwise noted.
 Stresses above these ratings may cause permanent damage.
 Exposure to absolute maximum ratings for extended periods may degrade reliability.

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Environmental and mechanical characteristics

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Ambient operating temperature	T_A	°C	-40		125	
Ambient storage temperature	$T_{A\ st}$	°C	-55		165	
Resistance of the primary @ $T_A = 25\ ^\circ\text{C}$	R_P	mΩ		0.76		
Thermal resistance junction to case ¹⁾	$R_{th\ JC}$	K/W		18		
Thermal resistance junction to ambient ¹⁾	$R_{th\ JA}$	K/W		19		
Mass	m	g		1.4		

Insulation coordination

Parameter	Symbol	Unit	≤ Value	Comment
RMS voltage for AC insulation test, 50 Hz, 1 min	U_d	kV	4.95	According to IEC 60950-1
Impulse withstand voltage 1.2/50 μs	U_{Ni}	kV	8	According to IEC 62109-1, IEC 61800-5-1
Partial discharge RMS test voltage ($q_m < 5\ \text{pC}$)	U_t	V	1650	According to IEC 62109-1, IEC 61800-5-1
Clearance (pri. - sec.)	d_{cl}	mm	8	Shortest distance through air
Creepage distance (pri. - sec.)	d_{cp}	mm	8	Shortest path along device body
Case material	-	-	V0	According to UL 94, flamability
Comparative tracking index	CTI		600	grade requirements mas compand
Application example System voltage RMS		V	1000	Basic insulation according to IEC 61800-5-1, IEC 62109-1, IEC 60950-1 CAT III, PD2
Application example System voltage RMS		V	600	Reinforced insulation according to IEC 61800-5-1, IEC 62109-1, IEC 60950-1 CAT III, PD2
Application example System voltage DC		V	1500	Basic insulation according to IEC 62109-1 CAT III, PD2
Application example System voltage DC		V	800	Reinforced insulation according to IEC 62109-1 CAT III, PD2

Note: ¹⁾ Done on LEM evaluation board PCB 6030:
<https://www.lem.com/en/hmsr-miniature-current-sensors>.

Electrical data HMSR 20-SMS/SP3

 At $T_A = 25\text{ °C}$, $U_C = +3.3\text{ V}$, $R_L = 10\text{ k}\Omega$, unless otherwise noted (see Min, Max, typ, definition paragraph in page 7).

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Primary nominal current	I_{PN}	A		20		
Primary current, measuring range	I_{PM}	A	-50		50	
Internal reference voltage @ $I_P = 0\text{ A}$	$U_{out} - U_{Iref}$	V	1.63	1.65	1.67	
Output voltage range @ I_{PM}	$U_{out} - U_{Iref}$	V	-1.15		1.15	
Output Internal resistance of U_{out}	R_{out}	Ω		2	5	
Output Internal resistance of U_{ref}	R_{ref}	Ω	120	200	333	
Load capacitance on U_{out}	C_L	nF	0	4.7	6	
Load capacitance on U_{ref}	C_L	nF	0	47	100	
DC supply voltage	U_C	V	3.135	3.3	3.465	
DC current consumption	I_C	mA		19	25	
Nominal sensitivity	S_N	mV/A		25		500 mV @ I_{PN}
Sensitivity error	ε_S	%	-0.75		0.75	Factory adjustment
Sum of sensitivity and linearity error @ $T_A = 25\text{ °C}$	ε_{SL25}	% of I_{PN}	-1.25		1.25	
Electrical offset voltage referred to primary	U_{OE}	mV	-5		5	$U_{out} - U_{Iref}$ @ $U_{Iref} = 1.65\text{ V}$
Electrical offset current referred to primary	I_{OE}	mA	-200		200	
Temperature coefficient of S	TCS	ppm/K	-250		250	-40 °C ... 125 °C
Temperature coefficient of U_{Iref}	TCU_{Iref}	ppm/K	-150		150	-40 °C ... 125 °C
Temperature coefficient of U_{OE}	TCU_{OE}	mV/K	-0.075		0.075	-40 °C ... 125 °C
Temperature coefficient of I_{OE} referred to primary	TCI_{OE}	mA/K	-3		3	-40 °C ... 125 °C
Magnetic offset current after overload ($I_P > 500\text{ A}$) referred to primary	I_{OM}	A		0.18		
Noise voltage spectral density referred to primary	u_{no}	$\mu\text{V}/\text{Hz}^{1/2}$		TBD		100 Hz ... 100 kHz
Internal OCD detection threshold	$I_{I OCD Th}$	A		$3.05 \times I_{PN}$		
Internal OCD threshold error	$\varepsilon_{I OCD Th}$	%		± 10		Referred to I_{PN}
Internal OCD output on resistance	$R_{on I OCD}$	Ω	70	95	100	Open drain output, active low
Linearity error 0 ... $\pm I_{PN}$	ε_L	%	-0.5		0.5	Referred to I_{PN}
Linearity error 0 ... $\pm I_{PM}$	ε_L	%	-0.5		0.5	Referred to I_{PM}
Delay time @ 10 % of the final output value I_{PN} step	$t_{D 10}$	μs			1.5	
Delay time @ 90 % of the final output value I_{PN} step	$t_{D 90}$	μs			2	
Internal OCD delay time	$t_{D I OCD}$	μs	1.4	1.7	2.1	
Frequency bandwidth (-3 dB)	BW	kHz		300		
Internal OCD output hold time	$t_{hold I OCD}$	μs	7	10	14	

Electrical data HMSR 30-SMS/SP3

 At $T_A = 25\text{ °C}$, $U_C = +3.3\text{ V}$, $R_L = 10\text{ k}\Omega$, unless otherwise noted (see Min, Max, typ, definition paragraph in page 7).

Parameter	Symbol	Unit	Min	Typ	Max	Comment
Primary nominal current	I_{PN}	A		30		
Primary current, measuring range	I_{PM}	A	-75		75	$T_A < 75\text{ °C}$
Internal reference voltage @ $I_P = 0\text{ A}$	$U_{out} - U_{Iref}$	V	1.63	1.65	1.67	
Output voltage range @ I_{PM}	$U_{out} - U_{Iref}$	V	-1.15		1.15	
Output Internal resistance of U_{out}	R_{out}	Ω		2	5	
Output Internal resistance of U_{ref}	R_{ref}	Ω	120	200	333	
Load capacitance on U_{out}	C_L	nF	0	4.7	6	
Load capacitance on U_{ref}	C_L	nF	0	47	100	
DC supply voltage	U_C	V	3.135	3.3	3.465	
DC current consumption	I_C	mA		19	25	
Nominal sensitivity	S_N	mV/A		16.67		500 mV @ I_{PN}
Sensitivity error	ε_s	%	-0.75		0.75	Factory adjustment
Sum of sensitivity and linearity error @ $T_A = 25\text{ °C}$	ε_{SL25}	% of I_{PN}	-1.25		1.25	
Electrical offset voltage referred to primary	U_{OE}	mV	-5		5	$U_{out} - U_{Iref}$ @ $U_{Iref} = 1.65\text{ V}$
Electrical offset current referred to primary	I_{OE}	mA	-300		300	
Temperature coefficient of S	TCS	ppm/K	-250		250	-40 °C ... 125 °C
Temperature coefficient of U_{Iref}	TCU_{Iref}	ppm/K	-150		150	-40 °C ... 125 °C
Temperature coefficient of U_{OE}	TCU_{OE}	mV/K	-0.075		0.075	-40 °C ... 125 °C
Temperature coefficient of I_{OE} referred to primary	TCI_{OE}	mA/K	-4.5		4.5	-40 °C ... 125 °C
Magnetic offset current after overload ($I_P > 500\text{ A}$) referred to primary	I_{OM}	A		0.18		
Noise voltage spectral density referred to primary	u_{no}	$\mu\text{V}/\text{Hz}^{1/2}$		TBD		100 Hz ... 100 kHz
Internal OCD detection threshold	$I_{I OCD Th}$	A		$3.05 \times I_{PN}$		
Internal OCD threshold error	$\varepsilon_{I OCD Th}$	%		± 10		Referred to I_{PN}
Internal OCD output on resistance	$R_{on I OCD}$	Ω	70	95	100	Open drain output, active low
Linearity error 0 ... $\pm I_{PN}$	ε_L	%	-0.5		0.5	Referred to I_{PN}
Linearity error 0 ... $\pm I_{PM}$	ε_L	%	-0.5		0.5	Referred to I_{PM}
Delay time @ 10 % of the final output value I_{PN} step	$t_{D 10}$	μs			1.5	
Delay time @ 90 % of the final output value I_{PN} step	$t_{D 90}$	μs			2	
Internal OCD delay time	$t_{D I OCD}$	μs	1.4	1.7	2.1	
Frequency bandwidth (-3 dB)	BW	kHz		300		
Internal OCD output hold time	$t_{hold I OCD}$	μs	7	10	14	

Note: 1) See figure 2.

Sum of sensitivity and linearity error

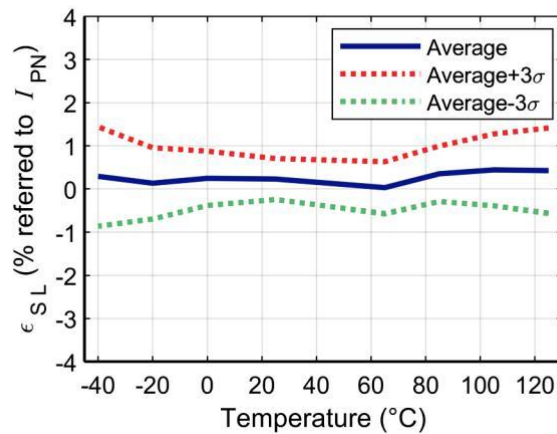


Figure 1: Typical value on HMSR 20-SMS/SP3

Measuring range vs ambient temperature

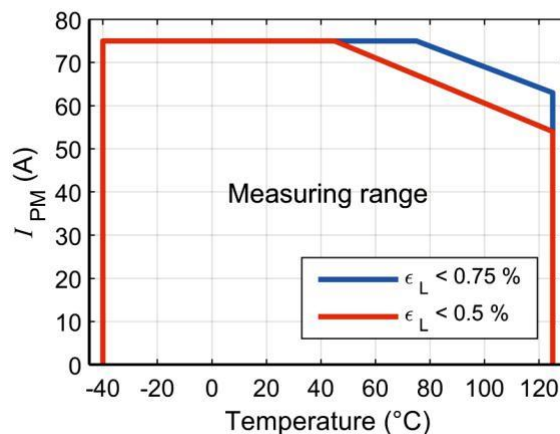


Figure 2

Definition of typical, minimum and maximum values

Minimum and maximum values for specified limiting and safety conditions have to be understood as such as well 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 $-\text{sigma}$ and $+\text{sigma}$ for a normal distribution.

Typical, maximal and minimal values are determined during the initial characterization of the product.

External overcurrent detection

Parameter	Symbol	Unit	Specification			Conditions
			Min	Typical	Max	
External OCD voltage	$U_{E\text{ OCD}}$	V	0.3		2.5	
External OCD output on resistance to ground	$R_{\text{on E OCD}}$	Ω	35	200	300	Open drain output, active low
External OCD delay time	$t_{\text{DE OCD}}$	μs	7	10	13	To be added to the sensor delay time
External OCD output hold time	$t_{\text{hold E OCD}}$	μs	7	10	14	
External OCD threshold error	$\varepsilon_{\text{EOCD}}$	%		± 6		Referred to I_{PN}

$I_{E\text{ OCD}}$: External overcurrent detection (OCD threshold) at $U_{\text{ref}} = 1.65\text{ V}$

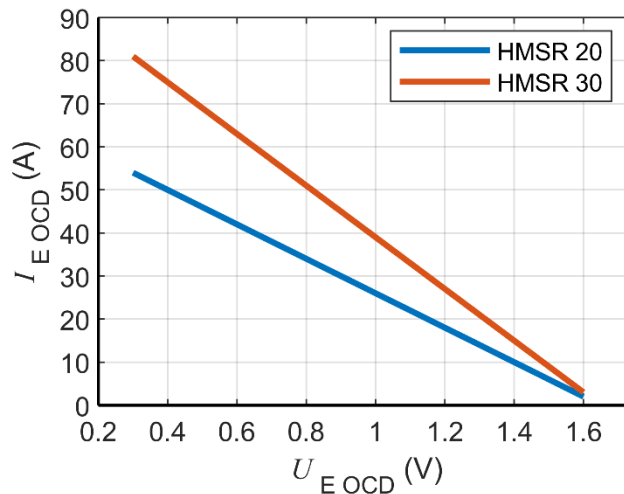


Figure 3

$$I_{E\text{ OCD}} = \frac{U_{\text{ref}} - U_{E\text{ OCD}}}{R_{\text{E}} + R_{\text{ref}}} \times U_{\text{ref}} \quad \text{with } 0.3 \leq U_{E\text{ OCD}} \leq U_{\text{ref}}$$

Pins definition

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	$U_{E\text{OCD}}$	External OCD threshold voltage terminal

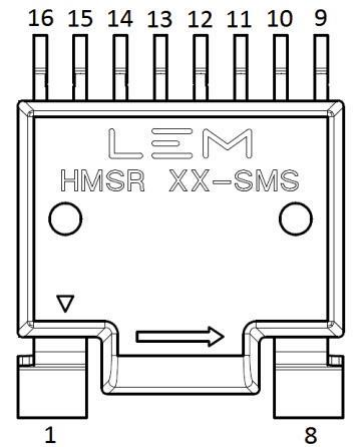


Figure 4

Block diagram

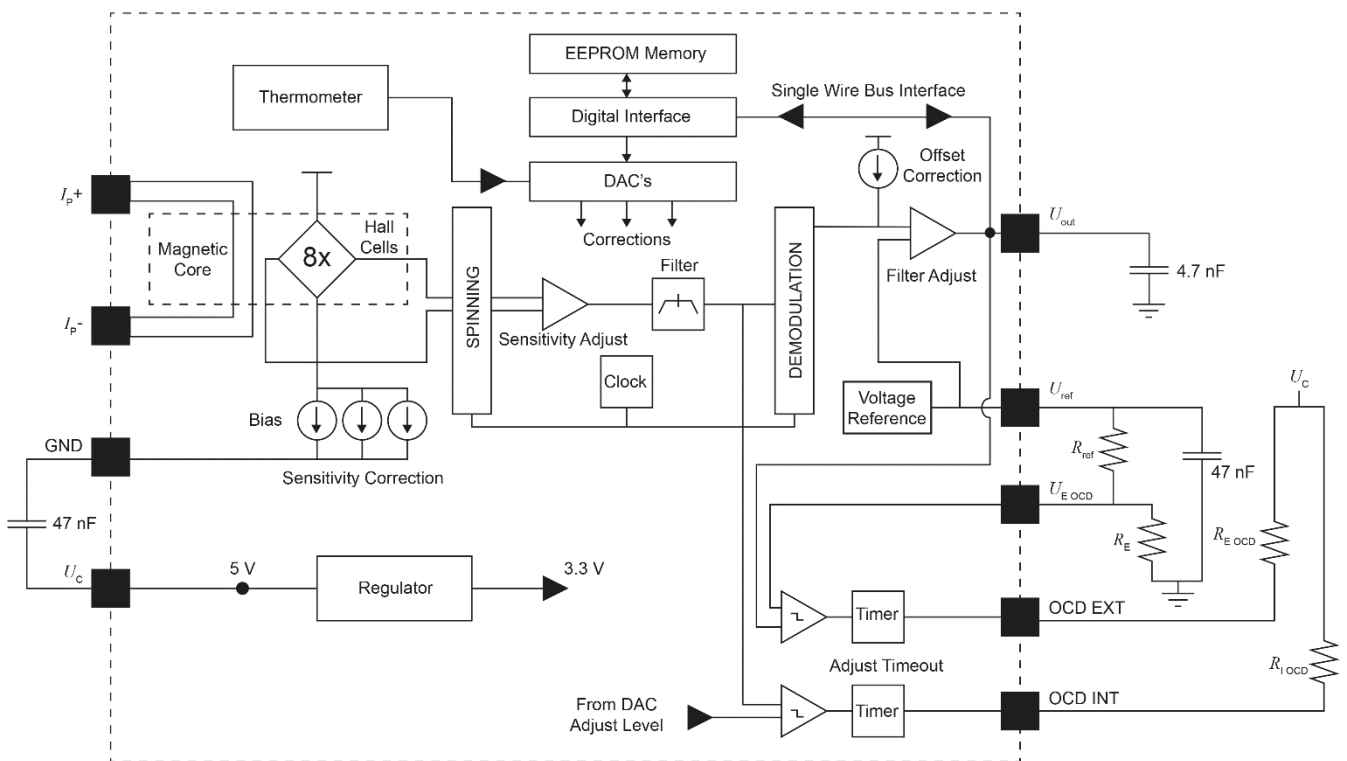


Figure 5

Total error referred to primary

The total error ϵ_{tot} is the error at $\pm I_{PN}$, relative to the rated value I_{PN} .

It includes all errors mentioned above

- the electrical offset I_{OE}
- the magnetic offset I_{OM}
- the sensitivity error ϵ_S
- the linearity error ϵ_L (to I_{PN}).

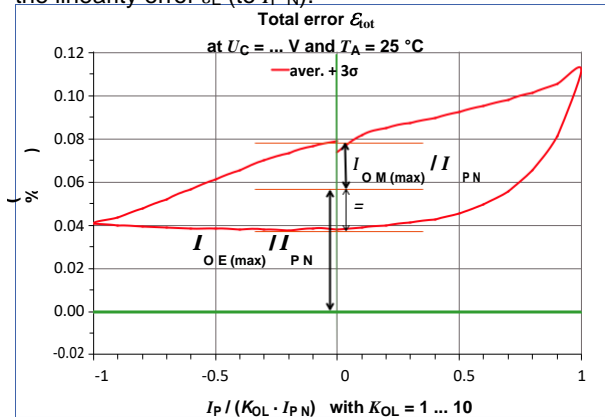


Figure 6: Total error ϵ_{tot}

Electrical offset referred to primary

Using the current cycle shown in figure 7, the electrical offset current I_{OE} is the residual output referred to primary when the input current is zero.

Magnetic offset referred to primary

$$I_{OE} = \frac{I_{P(3)} + I_{P(5)}}{2}$$

The magnetic offset current I_{OM} is the consequence of a current on the primary side ("memory effect" of the transducer's ferro-magnetic core). It is measured using the following primary current cycle. I_{OM} depends on the current value $I_P \geq I_{PN}$.

K_{OL} : Overload factor

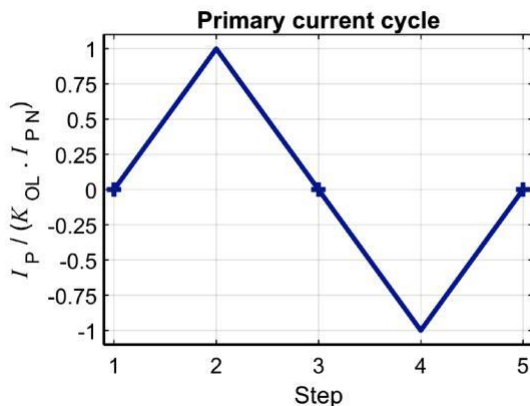


Figure 7: Current cycle used to measure magnetic and electrical offset (transducer supplied)

$$I_{OM} = \frac{I_{P(3)} - I_{P(5)}}{2}$$

Sensitivity and linearity

To measure sensitivity and linearity, the primary current (DC) is cycled from 0 to I_P , then to $-I_P$ and back to 0 (equally spaced $I_{PN}/10$ steps). The sensitivity S is defined as the slope of the linear regression line for a cycle between $\pm I_{PN}$.

The linearity error ϵ_L is the maximum positive or negative difference between the measured points and the linear regression line, expressed in % of I_{PN} .

Delay times

The delay time t_{D10} @ 10 % and the delay time t_{D90} @ 90 % with respect to the primary are shown in the next figure.

Both slightly depend on the primary current di/dt . They are measured at nominal current.

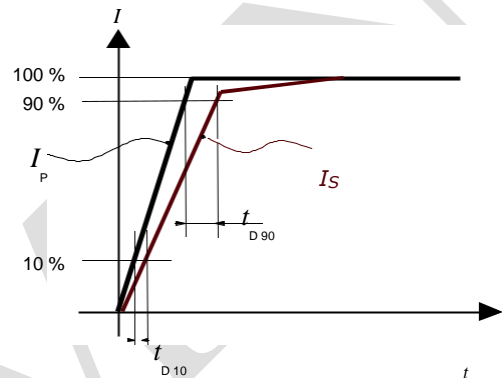


Figure 8: t_{D10} (delay time @ 10 %) and

t_{D90} (delay time @ 90 %).

PCB footprint (in mm)

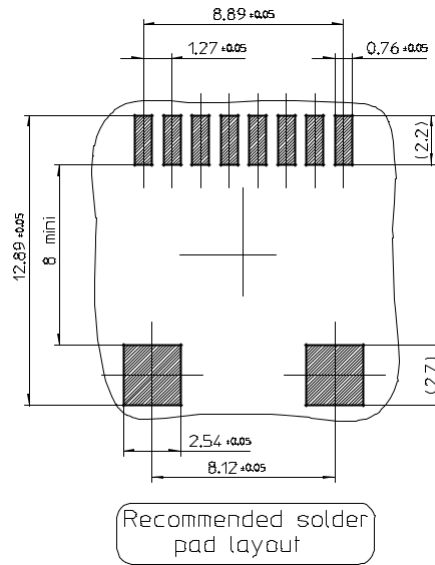


Figure 9

Soldering on PCB

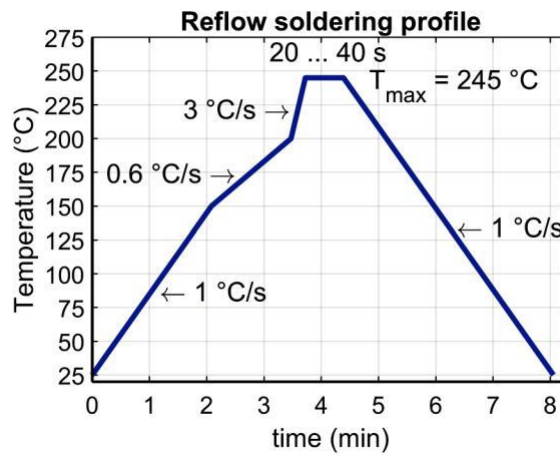
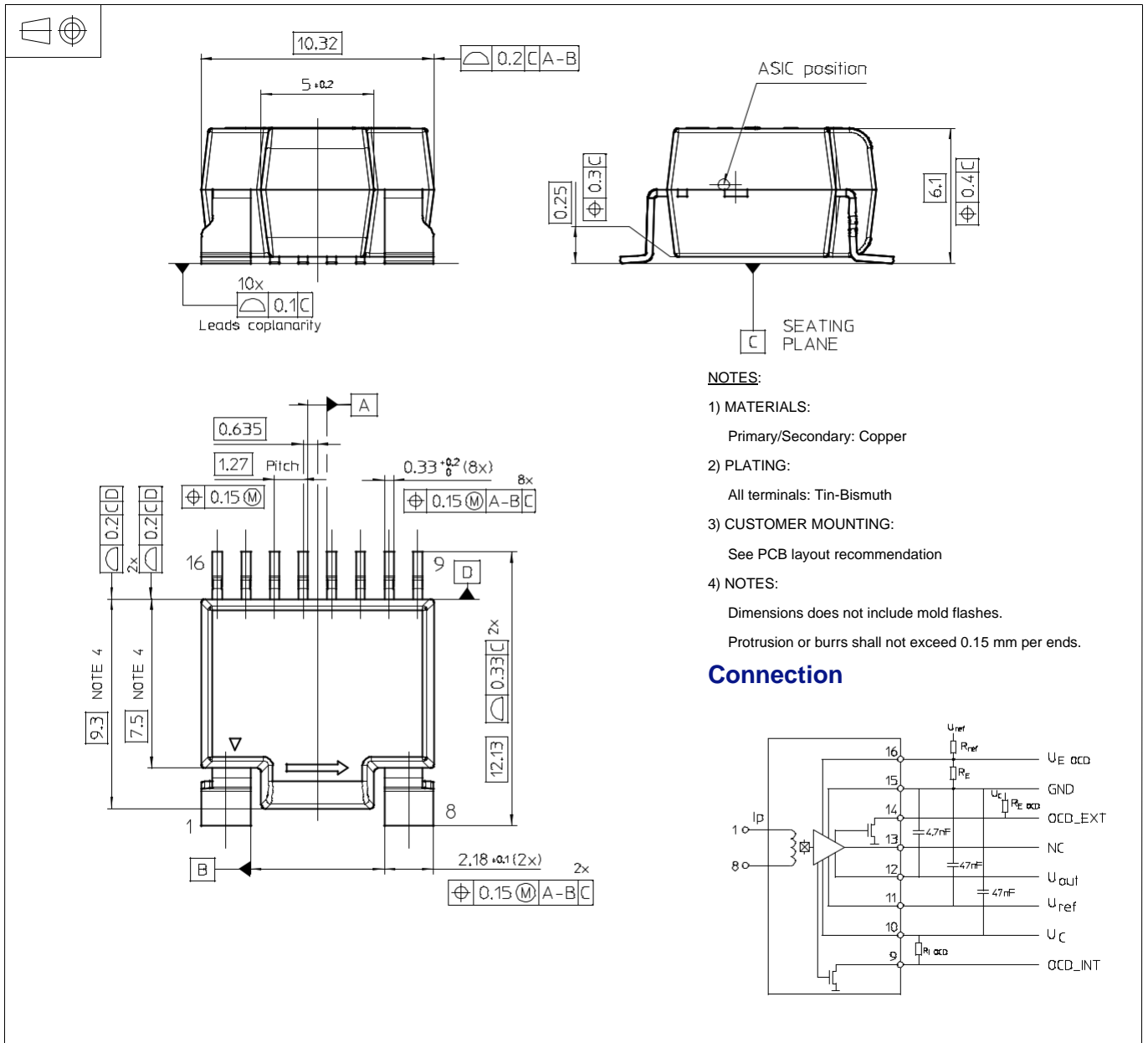


Figure 10

Soldering remarks:

- HMSR is qualified MSL1 for storage and mounting purposes.
- Per JEDEC J-STD-020E for packages more than 2.5 mm thick per table 4.2 (Pb-Free Process) of the specification.
- Best practice is to use 7 zones or greater conventional reflow system, limiting the time at reflow temperature as indicated in profile above.
- Rework not recommended.

Dimensions (in mm)



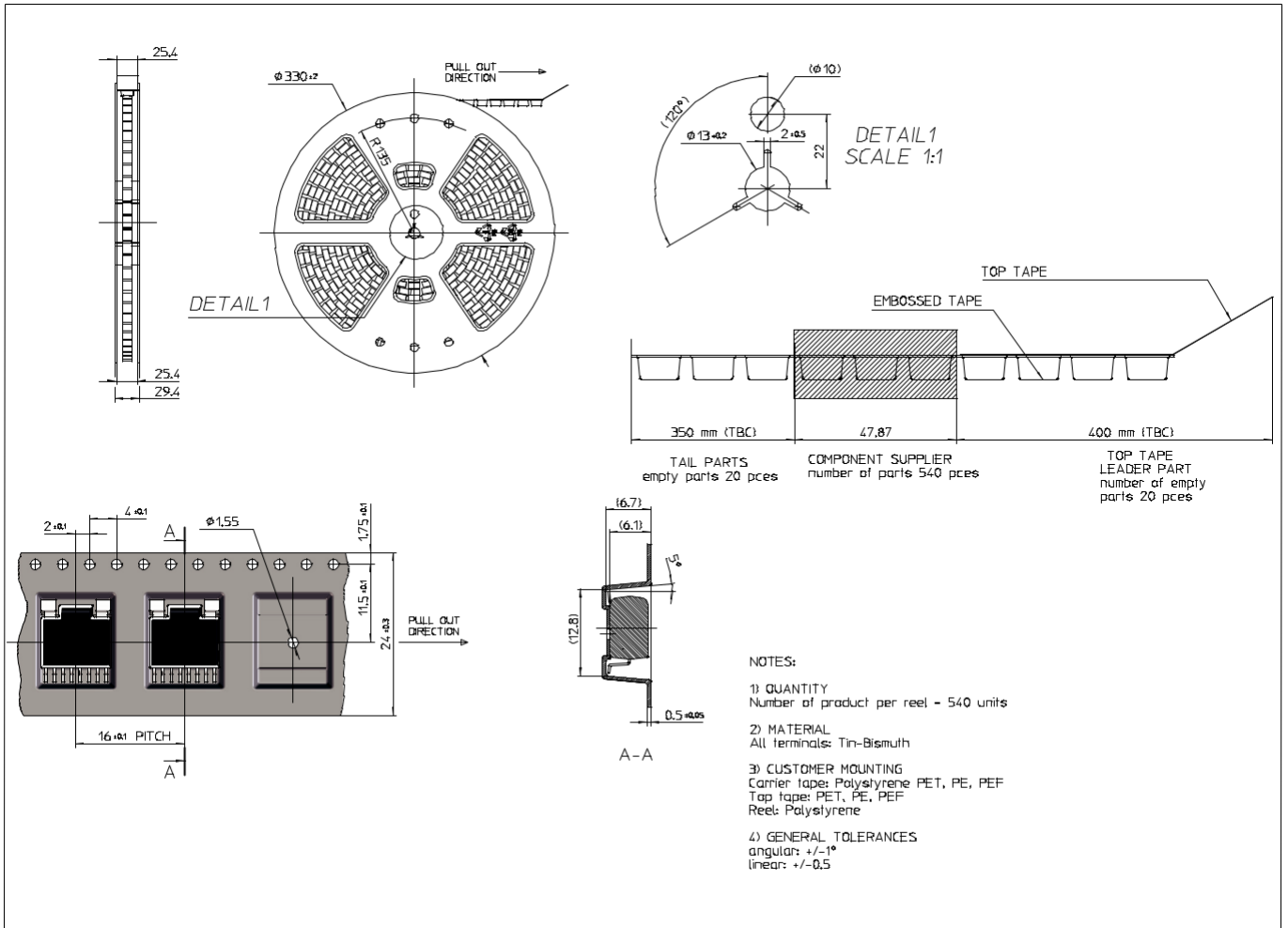
Mechanical characteristics

- General tolerance ± 0.15 mm

Remark

- $U_{out} - U_{ref}$ is positive when I_P flows in the direction of arrow (pin 1 to pin 8).

Tape and Reel (in mm)



SPEC