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MICRONAS

Hardware Documentation

Data Sheet

HAL® 202

Hall-Effect Sensor

Edition Sept. 18, 2014
DSH000159_002EN

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Contents

1. Introduction

Release Note: Revision bars indicate significant changes to the previous edition.

The HAL 202 Hall switch is produced in CMOS technology. The sensor includes a temperature-compensated Hall plate with active offset compensation, a comparator, and an open-drain output transistor. The comparator compares the actual magnetic flux through the Hall plate (Hall voltage) with the fixed reference values (switching points). Accordingly, the output transistor is switched on or off.

The active offset compensation leads to magnetic parameters which are robust against mechanical stress effects. In addition, the magnetic characteristics are constant in the full supply voltage and temperature range.

The sensor is designed for industrial and automotive applications and operates with supply voltages from 3.8 V to 24 V in the junction temperature range from –40 °C up to 170 °C.

The HAL 202 is available in the SMD package SOT89B-3 and in the leaded versions TO92UA-5 and TO92UA-6.

1.1. Features

– switching offset compensation

– operates from 3.8 V to 24 V supply voltage

– operates with static magnetic fields and dynamic magnetic fields up to 10 kHz

– overvoltage protection at all pins

– reverse-voltage protection at V_{DD}-pin

– magnetic characteristics are robust against mechanical stress effects

– short-circuit protected open-drain output by thermal shut down

– constant switching points over a wide supply voltage and temperature range

– the decrease of magnetic flux density caused by rising temperature in the sensor system is compensated by a built-in negative temperature coefficient of the magnetic characteristics

– superior temperature stability for automotive or industrial applications

– high ESD rating

– EMC corresponding to ISO 7637

1.2. Type Description

Latching Sensors:

The sensor has a latching behavior and require a magnetic north and south pole for correct functioning. The output turns low with the magnetic south pole on the branded side of the package and turns high with the magnetic north pole on the branded side. The output does not change if the magnetic field is removed. For changing the output state, the opposite magnetic field polarity must be applied.

2. Ordering Information

2.1. Marking Code

All Hall sensors have a marking on the package surface (branded side). This marking includes the name of the sensor and the temperature range.

Type	Temperature Range	
	A	K
HAL202	202A	202K

2.2. Operating Junction Temperature Range

The Hall sensors from Micronas are specified to the chip temperature (junction temperature T_J).

A: T_J = –40 °C to +170 °C

K: T_J = –40 °C to +140 °C

Note: Due to power dissipation, there is a difference between the ambient temperature (T_A) and junction temperature. Please refer to section 5.1. on page 14 for details.

Hall Sensor Package Codes

HALXXXPA-T

Temperature Range: A or K

Package: TQ for SOT89B-3
JQ for TO92UA-5/6

Type: 2xy

Example: **HAL202JQ-A**

→ Type: 202
→ Package: TO92UA-6
→ Temperature Range: T_J = –40 °C to +170 °C

Hall sensors are available in a wide variety of packaging versions and quantities. For more detailed information, please refer to the brochure: “Hall Sensors. Ordering Codes, Packaging, Handling”.

3. Functional Description

The Hall effect sensor is a monolithic integrated circuit that switches in response to magnetic fields. If a magnetic field with flux lines perpendicular to the sensitive area is applied to the sensor, the biased Hall plate forces a Hall voltage proportional to this field. The Hall voltage is compared with the actual threshold level in the comparator. The temperature-dependent bias increases the supply voltage of the Hall plates and adjusts the switching points to the decreasing induction of magnets at higher temperatures. If the magnetic field exceeds the threshold levels, the open drain output switches to the appropriate state. The built-in hysteresis eliminates oscillation and provides switching behavior of output without bouncing.

Magnetic offset caused by mechanical stress is compensated for by using the “switching offset compensation technique”. Therefore, an internal oscillator provides a two phase clock. The Hall voltage is sampled at the end of the first phase. At the end of the second phase, both sampled and actual Hall voltages are averaged and compared with the actual switching point. Subsequently, the open drain output switches to the appropriate state. The time from crossing the magnetic switching level to switching of output can vary between zero and $1/f_{osc}$.

Shunt protection devices clamp voltage peaks at the Output-pin and V_{DD}-pin together with external series resistors. Reverse current is limited at the V_{DD}-pin by an internal series resistor up to –15 V. No external reverse protection diode is needed at the V_{DD}-pin for reverse voltages ranging from 0 V to –15 V.

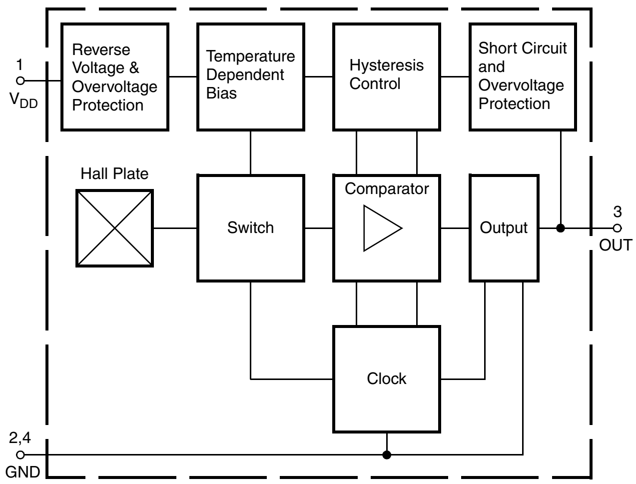
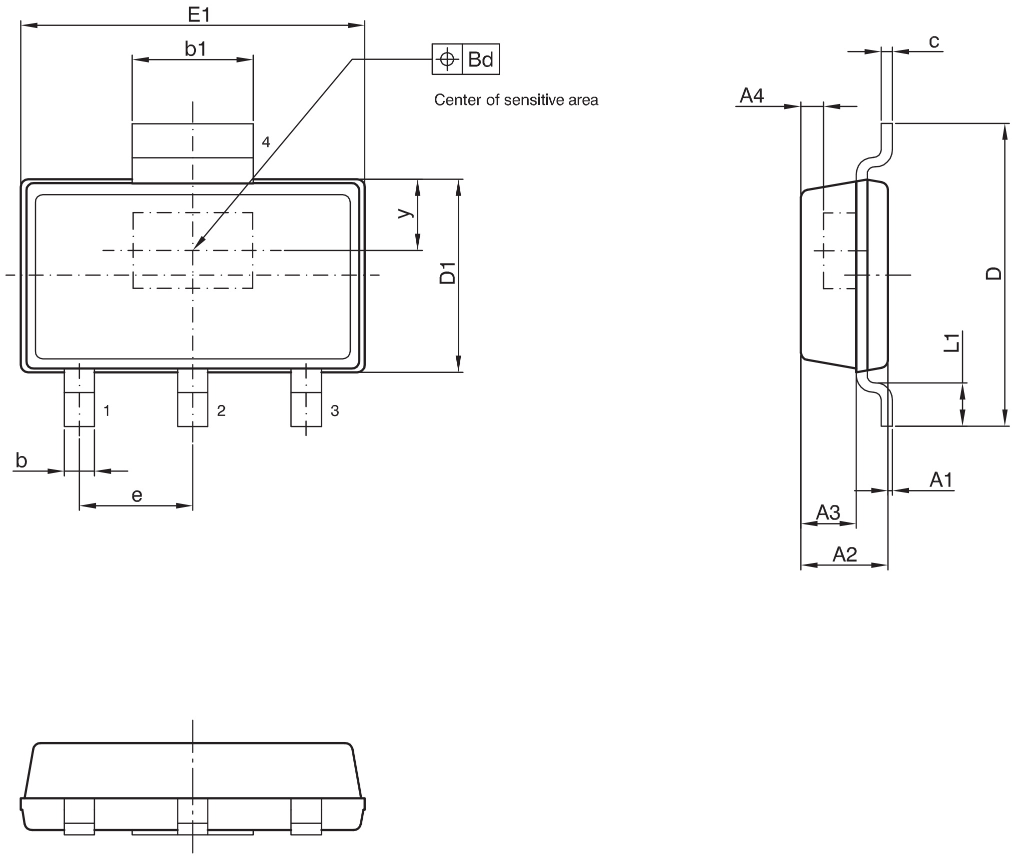


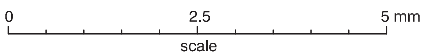
Fig. 3–1: HAL202 block diagram

4. Specifications

4.1. Outline Dimensions



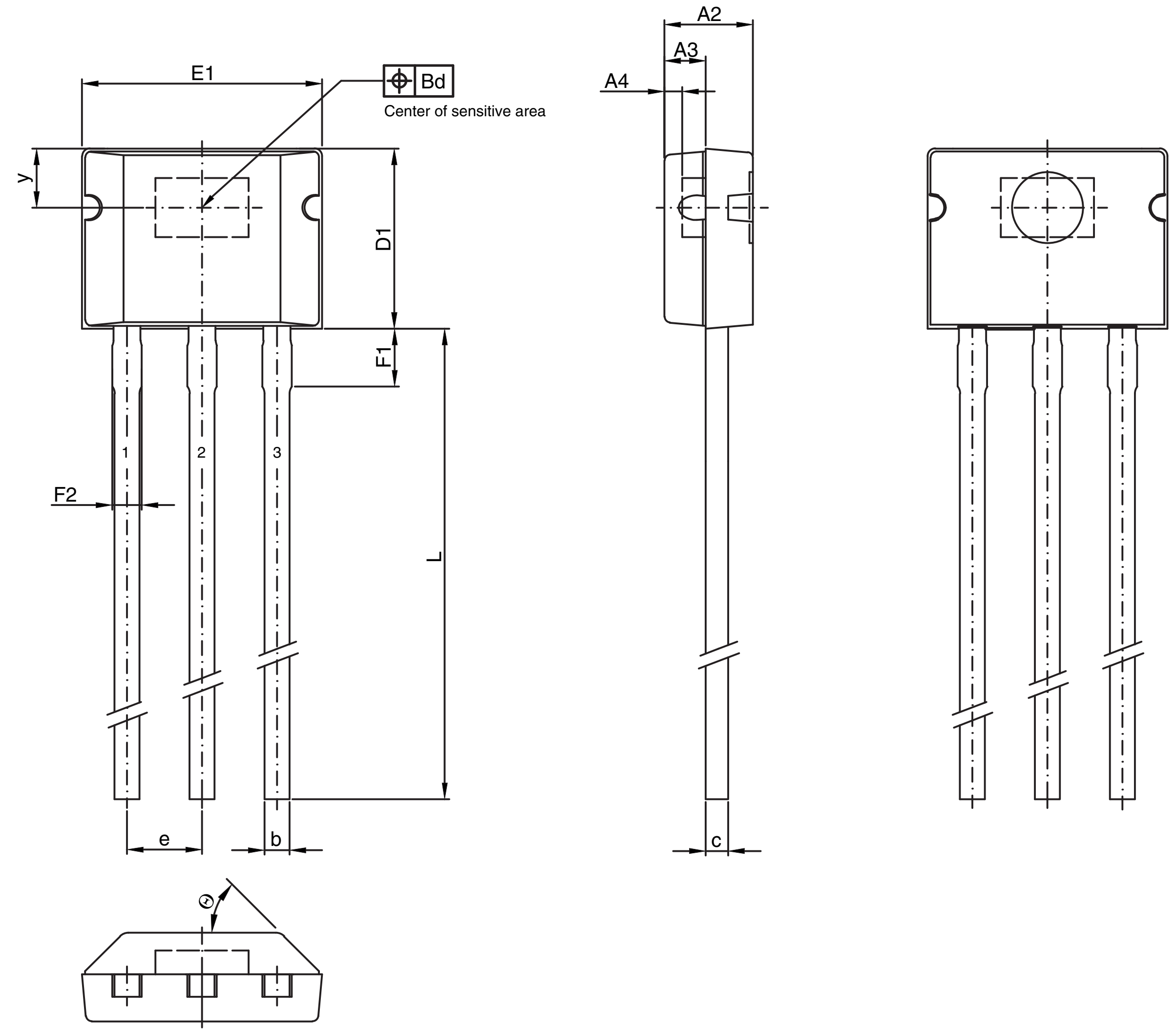
A4, y= this dimension is different for each sensor type and is specified in the data sheet.
physical dimensions do not include mold flash



UNIT	A1	A2	A3	b	b1	Bd	c	D	D1	e	E1	L1
mm	0.10 0.02	1.20 1.10	0.73	0.4	1.7	0.3	0.15	4.0	2.6 2.5	1.5	4.6 4.5	0.25 min.

JEDEC STANDARD		ANSI	ISSUE DATE YY-MM-DD	DRAWING-NO.	ZG-NO.
ISSUE	ITEM NO.				
-	-		07-05-29	06667.0001.4	ZG001067_Ver.02

Fig. 4–1:
SOT89B-3: Plastic **S**mall **O**utline **T**ransistor package, 4 leads, with one sensitive area
Weight approximately 0.034 g.

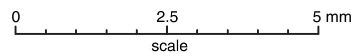


solderability is guaranteed between end of pin and distance F1.

Sn-thickness might be reduced by mechanical handling.

y= this dimension is different for each sensor type and is specified in the data sheet.

physical dimensions do not include mold flash.



UNIT	A2	A3	A4	b	Bd	c	D1	e	E1	F1	F2	L	Θ
mm	1.55 1.45	0.7	0.3	0.43	0.3	0.36	3.1 3.0	1.27	4.11 4.01	1.2 0.8	0.60 0.42	15.5 min	45°

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ISSUE	ITEM NO.				
-	-		07-05-30	06666.0001.4	ZG001066_Ver.05

Fig. 4–2:
TO92UA-6 Plastic Transistor Standard UA package, 3 leads, not spread
Weight approximately 0.105 g

4.2. Soldering, Welding and Assembly

Please check the Micronas Document "Guidelines for the Assembly of HAL Packages" for further informations about solderability, welding, assembly, and second-level packaging. The document is available on the Micronas website or on the service portal.

4.3. Pin Connections

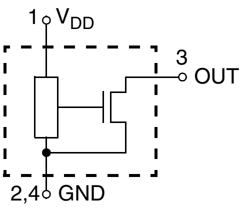

Fig. 4–1: Pin configuration

4.4. Dimensions of Sensitive Area

0.25 mm × 0.12 mm (on chip)

4.5. Positions of Sensitive Areas

	SOT89B-3	**TO92UA-5/6**
y	0.95 mm nominal	1.08 mm nominal
A4	0.33 mm nominal	0.30 mm nominal

4.6. Absolute Maximum Ratings

Stresses beyond those listed in the “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only. Functional operation of the device at these conditions is not implied. Exposure to absolute maximum rating conditions for extended periods will affect device reliability.

This device contains circuitry to protect the inputs and outputs against damage due to high static voltages or electric fields; however, it is advised that normal precautions be taken to avoid application of any voltage higher than absolute maximum-rated voltages to this high-impedance circuit.

All voltages listed are referenced to ground (GND).

Symbol	Parameter	Pin Name	Min.	Max.	Unit
V_{DD}	Supply Voltage	1	–15	28	V
V_O	Output Voltage	3	–0.3	28	V
I_O	Continuous Output On Current	3	–	50	mA
T_J	Junction Temperature Range A	–	–40	170[1]	°C
[1] t < 1000 h					

4.6.1. Storage and Shelf Life

The permissible storage time (shelf life) of the sensors is unlimited, provided the sensors are stored at a maximum of 30 °C and a maximum of 85% relative humidity. At these conditions, no Dry Pack is required.

Solderability is guaranteed for two years from the date code on the package.

4.7. Recommended Operating Conditions

Functional operation of the device beyond those indicated in the “Recommended Operating Conditions/Characteristics” is not implied and may result in unpredictable behavior, reduce reliability and lifetime of the device.

All voltages listed are referenced to ground (GND).

Symbol	Parameter	Pin Name	Min.	Max.	Unit	Conditions
V_{DD}	Supply Voltage	1	3.8	24	V	
I_O	Continuous Output on Current	3	0	20	mA	
V_O	Output Voltage (output switched off)	3	0	24	V	
T_J	Junction temperature range[1]	–	–40 –40 –40	125 140 170	°C °C °C	t < 8000 h[2] t < 2000 h[2] t < 1000 h[2]
[1] Depends on the temperature profile of the application. Please contact Micronas for life time calculations. [2] No cumulative stress						

4.8. Characteristics

at T_J = –40 °C to +170 °C, V_{DD} = 3.8 V to 24 V, GND = 0 V
at Recommended Operation Conditions if not otherwise specified in the column "Conditions".
Typical Characteristics for T_J = 25 °C and V_{DD} = 12 V.
For all other temperature ranges this table is also valid, but only in the junction temperature range defined by the temperature grade (Example: For K-Type this table is limited to T_J = –40 °C to +140 °C).

Symbol	Parameter	Pin No.	Min.	Typ.	Max.	Unit	Conditions
I_{DD}	Supply Current over Temperature Range	1	1.6	3	5.2	mA	
V_{DDZ}	Overvoltage Protection at Supply	1	–	28.5	32	V	I_{DD} = 25 mA, T_J = 25 °C, t = 20 ms
V_{OZ}	Overvoltage Protection at Output	3	–	28	32	V	I_{OH} = 25 mA, T_J = 25 °C, t = 20 ms
V_{OL}	Output Voltage over Temperature Range	3	–	130	400	mV	I_{OL} = 20 mA
I_{OH}	Output Leakage Current over Temperature Range	3	–	–	10	µA	Output switched off, T_J ≤150 °C, V_{OH} = 3.8 to 24
f_{osc}	Internal Oscillator Chopper Frequency over Temperature Range	–	–	62	–	kHz	
$t_{en(O)}$	Enable Time of Output after Setting of V_{DD}	1	–	35	–	µs	V_{DD} = 12 V
t_r	Output Rise Time	3	–	75	400	ns	V_{DD} = 12 V, R_L = 820 Ohm, C_L = 20 pF
t_f	Output Fall Time	3	–	50	400	ns	
SOT89B Package							
 R_{thja} R_{thjc}	Thermal Resistance Junction to Ambient Junction to Case	 – –	 – –	 – –	 212 73	 K/W K/W	Measured with a 1s0p board 30 mm x 10 mm x 1.5 mm, pad size (see Fig. 4–2)
TO92UA Package							
 R_{thja} R_{thjc}	Thermal Resistance Junction to Ambient Junction to Case	 – –	 – –	 – –	 225 63	 K/W K/W	Measured with a 1s0p board

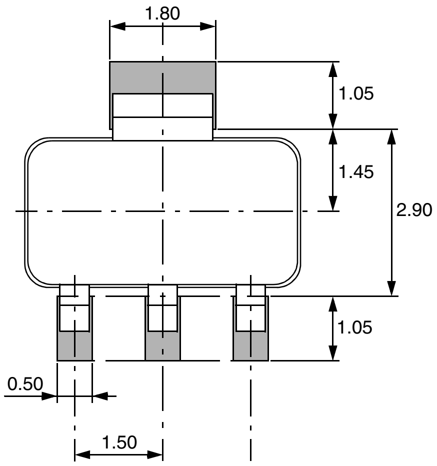

Fig. 4–2: Recommended footprint SOT89B-3,
Dimensions in mm
All dimensions are for reference only. The pad size may vary depending on the requirements of the soldering process.

4.9. Magnetic Characteristics Overview

at T_J = –40 °C to +170 °C, V_{DD} = 3.8 V to 24 V,
Typical Characteristics for V_{DD} = 12 V. Magnetic flux density values of switching points.
Positive flux density values refer to the magnetic south pole at the branded side of the package.
For all other temperature ranges this table is also valid, but only in the junction temperature range defined by the temperature grade (Example: For K-Type this table is limited to T_J = –40 °C to +140 °C).

Sensor	Parameter	On point B_{ON}			Off point B_{OFF}			Hysteresis B_{HYS}			Unit
Switching Type	**T_J**	**Min.**	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**	
HAL 202	–40 °C	0.5	2.8	6.5	–6.5	–2.8	–0.5	–	5.6	–	mT
latching	25 °C	0.5	2.6	6	–6	–2.6	–0.5	–	5.2	–	mT
	140 °C	0.1	2.4	5.5	–5.5	–2.4	–0.1	–	4.8	–	mT
	170 °C	0.1	2.4	5.5	–5.5	–2.4	–0.1	–	4.8	–	mT

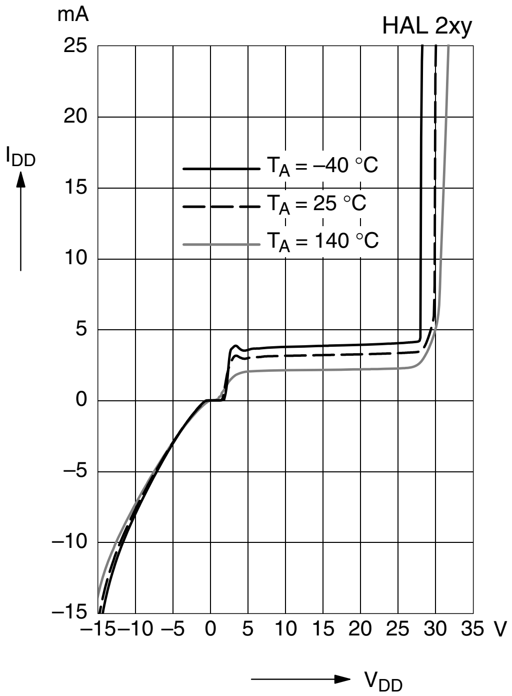

Fig. 4–3: Typical supply current versus supply voltage

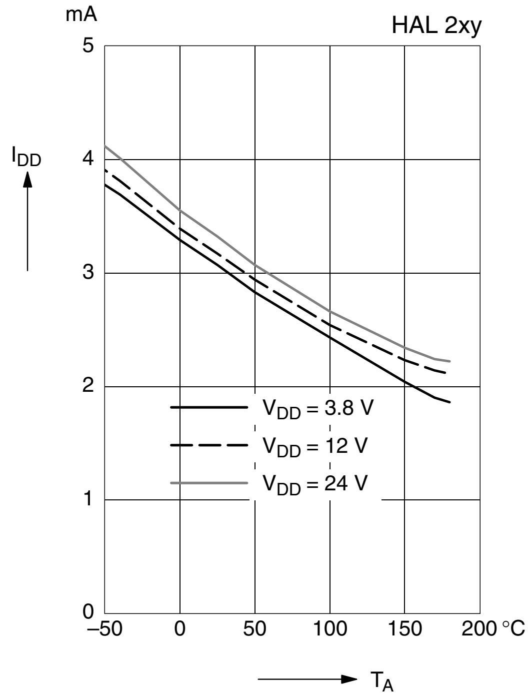

Fig. 4–5: Typical supply current versus ambient temperature

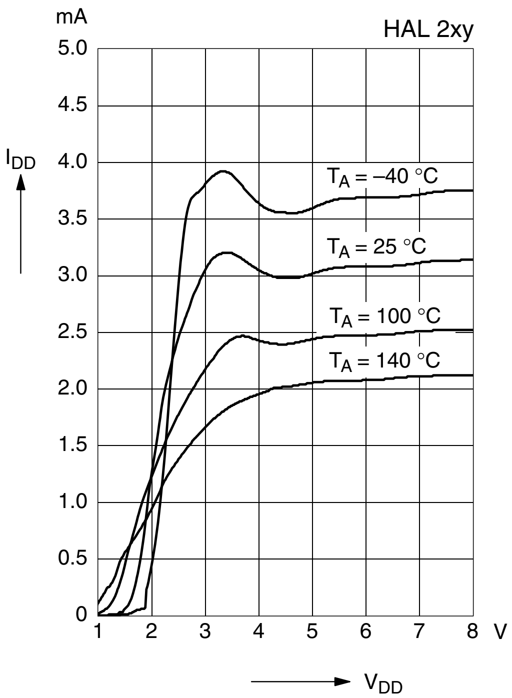

Fig. 4–4: Typical supply current versus supply voltage

5. Application Notes

5.1. Ambient Temperature

Due to the internal power dissipation, the temperature on the silicon chip (junction temperature T_J) is higher than the temperature outside the package (ambient temperature T_A).

$$T_J = T_A + \Delta T$$

At static conditions and continuous operation, the following equation applies:

$$\Delta T = I_{DD} \times V_{DD} \times R_{th}$$

If $I_{OUT} > I_{DD}$, please contact Micronas application support for detailed instructions on calculating ambient temperature.

For typical values, use the typical parameters. For worst case calculation, use the max. parameters for I_{DD} and R_{th}, and the max. value for V_{DD} from the application.

For all sensors, the junction temperature range T_J is specified. The maximum ambient temperature T_{Amax} can be calculated as:

$$T_{Amax} = T_{Jmax} - \Delta T$$

5.2. Operation

5.2.1. Extended Operating Conditions

All HAL202-sensors fulfill the electrical and magnetic characteristics when operated within the Recommended Operating Conditions (see page 10).

Supply Voltage Below 3.8 V

Typically, the sensor operates with supply voltages above 3 V, however, below 3.8 V some characteristics may be outside the specification.

Note: The functionality of the sensor below 3.8 V is not tested. For special test conditions, please contact Micronas.

5.2.2. Start-up Behavior

Due to the active offset compensation, the sensor has an initialization time (enable time $t_{en(O)}$) after applying the supply voltage. The parameter $t_{en(O)}$ is specified in Section 4.8.: Characteristics on page 11.

During the initialization time, the output state is not defined and the output can toggle. After $t_{en(O)}$, the output will be low if the applied magnetic field B is above B_{ON}. The output will be high if B is below B_{OFF}.

For magnetic fields between B_{OFF} and B_{ON}, the output state of the HAL sensor after applying V_{DD} will be either low or high. In order to achieve a well-defined output state, the applied magnetic field must be above B_{ONmax}, respectively, below B_{OFFmin}.

5.3. EMC and ESD

For applications with disturbances on the supply line or radiated disturbances, a series resistor and a capacitor are recommended (see Fig. 5–1). The series resistor and the capacitor should be placed as closely as possible to the HAL sensor.

Applications with this arrangement passed the EMC tests according to the product standards ISO 7637.

Please contact Micronas for the detailed investigation reports with the EMC and ESD results.

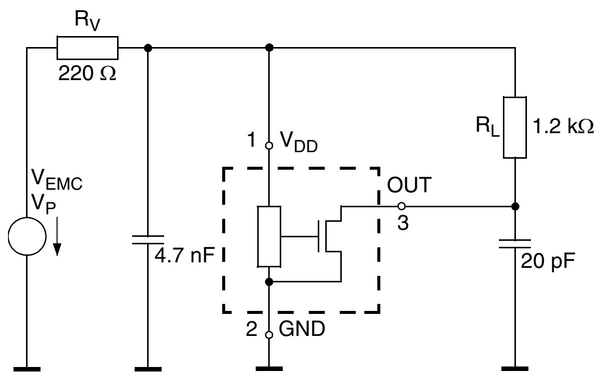

Fig. 5–1: Test circuit for EMC investigation

6. Data Sheet History

1. Data Sheet: “HAL 202 Hall-Effect Sensor”, July 21, 2011, DSH000159_001EN. First release of the data sheet.

2. Data Sheet: “HAL 202 Hall-Effect Sensor”, Sept. 18, 2014, DSH000159_002EN. Second release of the data sheet.

   Major Change:

   - Temperature Range K added

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